

PRACTICE GUIDELINE

## 2011 ACCF/AHA/SCAI Guideline for Percutaneous Coronary Intervention: Executive Summary

A Report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines and the Society for Cardiovascular Angiography and Interventions

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<b>Preamble</b> .....	

The medical profession should play a central role in evaluating the evidence related to drugs, devices, and procedures for the detection, management, and prevention of disease. When properly applied, expert analysis of available data on the benefits and risks of these therapies and procedures can improve the quality of care, optimize patient outcomes, and favorably affect costs by focusing resources on the most effective strategies. An organized and directed approach to a thorough review of evidence has resulted in the production of clinical practice guidelines that assist physicians in selecting the best management strategy for an individual patient. Moreover, clinical practice guidelines can provide a foundation for other applications, such as performance measures, appropriate use criteria, and both quality improvement and clinical decision support tools.

The American College of Cardiology Foundation (ACCF) and the American Heart Association (AHA) have jointly produced guidelines in the area of cardiovascular disease since 1980. The ACCF/AHA Task Force on Practice Guidelines (Task Force), charged with developing, up-

dating, and revising practice guidelines for cardiovascular diseases and procedures, directs and oversees this effort. Writing committees are charged with regularly reviewing and evaluating all available evidence to develop balanced, patient-centric recommendations for clinical practice.

Experts in the subject under consideration are selected by the ACCF and AHA to examine subject-specific data and write guidelines in partnership with representatives from other medical organizations and specialty groups. Writing committees are asked to perform a formal literature review; weigh the strength of evidence for or against particular tests, treatments, or procedures; and include estimates of expected outcomes where such data exist. Patient-specific modifiers, comorbidities, and issues of patient preference that may influence the choice of tests or therapies are considered. When available, information from studies on cost is considered, but data on efficacy and outcomes constitute the primary basis for the recommendations contained herein.

In analyzing the data and developing recommendations and supporting text, the writing committee uses evidence-based methodologies developed by the Task Force (1). The Class of Recommendation (COR) is an estimate of the size of the treatment effect considering risks versus benefits in addition to evidence and/or agreement that a given treatment or procedure is or is not useful/effective or in some situations may cause harm. The Level of Evidence (LOE) is an estimate of the certainty or precision of the treatment effect. The writing committee reviews and ranks evidence supporting each recommendation with the weight of evidence ranked as LOE A, B, or C according to specific definitions that are included in Table 1. Studies are identified as observational, retrospective, prospective, or randomized where appropriate. For certain conditions for which inadequate data are available, recommendations are based on expert consensus and clinical experience and are ranked as LOE C. When recommendations at LOE C are supported by historical clinical data, appropriate references (including clinical reviews) are cited if available. For issues for which sparse data are available, a survey of current practice among the clinicians on the writing committee is the basis for LOE C recommendations and no references are cited. The schema for COR and LOE is summarized in Table 1, which also provides suggested phrases for writing recommendations within each COR. A new addition to this methodology is separation of the Class III recommendations to delineate if the recommendation is determined to be of “no benefit” or is associated with “harm” to the patient. In addition, in view of the increasing number of comparative effectiveness studies, comparator verbs and suggested phrases for writing recommendations for the comparative effectiveness of one treatment or strategy versus another have been added for COR I and IIa, LOE A or B only.

In view of the advances in medical therapy across the spectrum of cardiovascular diseases, the Task Force has designated the term *guideline-directed medical therapy*

(*GDMT*) to represent optimal medical therapy as defined by ACCF/AHA guideline recommended therapies (primarily Class I). This new term, *GDMT*, will be used herein and throughout all future guidelines.

Because the ACCF/AHA practice guidelines address patient populations (and healthcare providers) residing in North America, drugs that are not currently available in North America are discussed in the text without a specific COR. For studies performed in large numbers of subjects outside North America, each writing committee reviews the potential influence of different practice patterns and patient populations on the treatment effect and relevance to the ACCF/AHA target population to determine whether the findings should inform a specific recommendation.

The ACCF/AHA practice guidelines are intended to assist healthcare providers in clinical decision making by describing a range of generally acceptable approaches to the diagnosis, management, and prevention of specific diseases or conditions. The guidelines attempt to define practices that meet the needs of most patients in most circumstances. The ultimate judgment regarding care of a particular patient must be made by the healthcare provider and patient in light of all the circumstances presented by that patient. As a result, situations may arise for which deviations from these guidelines may be appropriate. Clinical decision making should involve consideration of the quality and availability of expertise in the area where care is provided. When these guidelines are used as the basis for regulatory or payer decisions, the goal should be improvement in quality of care. The Task Force recognizes that situations arise in which additional data are needed to inform patient care more effectively; these areas will be identified within each respective guideline when appropriate.

Prescribed courses of treatment in accordance with these recommendations are effective only if followed. Because lack of patient understanding and adherence may adversely affect outcomes, physicians and other healthcare providers should make every effort to engage the patient’s active participation in prescribed medical regimens and lifestyles. In addition, patients should be informed of the risks, benefits, and alternatives to a particular treatment and be involved in shared decision making whenever feasible, particularly for COR IIa and IIb, where the benefit-to-risk ratio may be lower.

The Task Force makes every effort to avoid actual, potential, or perceived conflicts of interest that may arise as a result of industry relationships or personal interests among the members of the writing committee. All writing committee members and peer reviewers of the guideline are required to disclose all such current relationships, as well as those existing 12 months previously. In December 2009, the ACCF and AHA implemented a new policy for relationships with industry and other entities (RWI) that requires the writing committee chair plus a minimum of 50% of the writing committee to have no *relevant* RWI (Appendix 1 for the ACCF/AHA definition of relevance). These statements

**Table 1. Applying Classification of Recommendations and Level of Evidence**

		SIZE OF TREATMENT EFFECT													
ESTIMATE OF CERTAINTY (PRECISION) OF TREATMENT EFFECT		CLASS I <i>Benefit &gt;&gt;&gt; Risk</i> Procedure/Treatment <b>SHOULD</b> be performed/ administered	CLASS IIa <i>Benefit &gt;&gt; Risk</i> Additional studies with focused objectives needed <b>IT IS REASONABLE</b> to per- form procedure/administer treatment	CLASS IIb <i>Benefit ≥ Risk</i> Additional studies with broad objectives needed; additional registry data would be helpful  Procedure/Treatment <b>MAY BE CONSIDERED</b>	CLASS III <i>No Benefit</i> or CLASS III <i>Harm</i>										
					<table><tr><th></th><th>Procedure/ Test</th><th>Treatment</th></tr><tr><td>COR III: No benefit</td><td>Not Helpful</td><td>No Proven Benefit</td></tr><tr><td>COR III: Harm</td><td>Excess Cost w/o Benefit or Harmful</td><td>Harmful to Patients</td></tr></table>		Procedure/ Test	Treatment	COR III: No benefit	Not Helpful	No Proven Benefit	COR III: Harm	Excess Cost w/o Benefit or Harmful	Harmful to Patients	
		Procedure/ Test	Treatment												
	COR III: No benefit	Not Helpful	No Proven Benefit												
	COR III: Harm	Excess Cost w/o Benefit or Harmful	Harmful to Patients												
LEVEL A Multiple populations evaluated* Data derived from multiple randomized clinical trials or meta-analyses	<ul style="list-style-type: none"><li>■ Recommendation that procedure or treatment is useful/effective</li><li>■ Sufficient evidence from multiple randomized trials or meta-analyses</li></ul>	<ul style="list-style-type: none"><li>■ Recommendation in favor of treatment or procedure being useful/effective</li><li>■ Some conflicting evidence from multiple randomized trials or meta-analyses</li></ul>	<ul style="list-style-type: none"><li>■ Recommendation's usefulness/efficacy less well established</li><li>■ Greater conflicting evidence from multiple randomized trials or meta-analyses</li></ul>	<ul style="list-style-type: none"><li>■ Recommendation that procedure or treatment is not useful/effective and may be harmful</li><li>■ Sufficient evidence from multiple randomized trials or meta-analyses</li></ul>											
LEVEL B Limited populations evaluated* Data derived from a single randomized trial or nonrandomized studies	<ul style="list-style-type: none"><li>■ Recommendation that procedure or treatment is useful/effective</li><li>■ Evidence from single randomized trial or nonrandomized studies</li></ul>	<ul style="list-style-type: none"><li>■ Recommendation in favor of treatment or procedure being useful/effective</li><li>■ Some conflicting evidence from single randomized trial or nonrandomized studies</li></ul>	<ul style="list-style-type: none"><li>■ Recommendation's usefulness/efficacy less well established</li><li>■ Greater conflicting evidence from single randomized trial or nonrandomized studies</li></ul>	<ul style="list-style-type: none"><li>■ Recommendation that procedure or treatment is not useful/effective and may be harmful</li><li>■ Evidence from single randomized trial or nonrandomized studies</li></ul>											
LEVEL C Very limited populations evaluated* Only consensus opinion of experts, case studies, or standard of care	<ul style="list-style-type: none"><li>■ Recommendation that procedure or treatment is useful/effective</li><li>■ Only expert opinion, case studies, or standard of care</li></ul>	<ul style="list-style-type: none"><li>■ Recommendation in favor of treatment or procedure being useful/effective</li><li>■ Only diverging expert opinion, case studies, or standard of care</li></ul>	<ul style="list-style-type: none"><li>■ Recommendation's usefulness/efficacy less well established</li><li>■ Only diverging expert opinion, case studies, or standard of care</li></ul>	<ul style="list-style-type: none"><li>■ Recommendation that procedure or treatment is not useful/effective and may be harmful</li><li>■ Only expert opinion, case studies, or standard of care</li></ul>											
Suggested phrases for writing recommendations		should is recommended is indicated is useful/effective/beneficial	is reasonable can be useful/effective/beneficial is probably recommended or indicated	may/might be considered may/might be reasonable usefulness/effectiveness is unknown/unclear/uncertain or not well established	<table><tr><td>COR III: No Benefit</td><td>COR III: Harm</td></tr><tr><td>is not recommended</td><td>potentially harmful</td></tr><tr><td>is not indicated</td><td>causes harm</td></tr><tr><td>should not be performed/ administered/ other</td><td>associated with excess morbidity/mortality</td></tr><tr><td>is not useful/ beneficial/ effective</td><td>should not be performed/ administered/ other</td></tr></table>	COR III: No Benefit	COR III: Harm	is not recommended	potentially harmful	is not indicated	causes harm	should not be performed/ administered/ other	associated with excess morbidity/mortality	is not useful/ beneficial/ effective	should not be performed/ administered/ other
COR III: No Benefit	COR III: Harm														
is not recommended	potentially harmful														
is not indicated	causes harm														
should not be performed/ administered/ other	associated with excess morbidity/mortality														
is not useful/ beneficial/ effective	should not be performed/ administered/ other														
Comparative effectiveness phrases <sup>†</sup>		treatment/strategy A is recommended/indicated in preference to treatment B treatment A should be chosen over treatment B	treatment/strategy A is probably recommended/indicated in preference to treatment B it is reasonable to choose treatment A over treatment B												

A recommendation with Level of Evidence B or C does not imply that the recommendation is weak. Many important clinical questions addressed in the guidelines do not lend themselves to clinical trials. Although randomized trials are unavailable, there may be a very clear clinical consensus that a particular test or therapy is useful or effective.

\*Data available from clinical trials or registries about the usefulness/efficacy in different subpopulations, such as sex, age, history of diabetes, history of prior myocardial infarction, history of heart failure, and prior aspirin use. †For comparative effectiveness recommendations (Class I and IIa; Level of Evidence A and B only), studies that support the use of comparator verbs should involve direct comparisons of the treatments or strategies being evaluated.

are reviewed by the Task Force and all members during each conference call and/or meeting of the writing committee and are updated as changes occur. All guideline recommendations require a confidential vote by the writing committee and must be approved by a consensus of the voting members. Members are not permitted to write, and must recuse themselves from voting on, any recommendation or section to which their RWI apply. Members who recused themselves from voting are indicated in the list of writing committee members, and section recusals are noted in Appendix 1. Authors' and peer reviewers' RWI pertinent to this guideline are disclosed in Appendixes 1 and 2, respectively. Additionally, to ensure complete transparency, writing committee members' comprehensive disclosure information—including RWI not

pertinent to this document—is available as an [online supplement](#). Comprehensive disclosure information for the Task Force is also available online at [www.cardiosource.org/ACCF/About-ACCF/Leadership/Guidelines-and-Documents-Task-Forces.aspx](http://www.cardiosource.org/ACCF/About-ACCF/Leadership/Guidelines-and-Documents-Task-Forces.aspx). The work of the writing committee was supported exclusively by the ACCF, AHA, and the Society for Cardiovascular Angiography and Interventions (SCAI) without commercial support. Writing committee members volunteered their time for this activity.

In an effort to maintain relevance at the point of care for practicing physicians, the Task Force continues to oversee an ongoing process improvement initiative. As a result, in response to pilot projects, several changes to these guidelines will be apparent, including limited narrative text, a



focus on summary and evidence tables (with references linked to abstracts in PubMed), and more liberal use of summary recommendation tables (with references that support LOE) to serve as a quick reference.

In April 2011 the Institute of Medicine released 2 reports: *Finding What Works in Health Care: Standards for Systematic Reviews and Clinical Practice Guidelines We Can Trust* (2,3). It is noteworthy that the ACCF/AHA guidelines are cited as being compliant with many of the proposed standards. A thorough review of these reports and of our current methodology is under way, with further enhancements anticipated.

The recommendations in this guideline are considered current until they are superseded by a focused update or the full-text guideline is revised. Guidelines are official policy of both the ACCF and AHA.

Alice K. Jacobs, MD, FACC, FAHA  
Chair, ACCF/AHA Task Force on Practice Guidelines

## 1. Introduction

### 1.1. Methodology and Evidence Review

The recommendations listed in this document are, whenever possible, evidence based. An extensive evidence review was conducted through November 2010, as well as selected other references through August 2011. Searches were limited to studies, reviews, and other evidence conducted in human subjects and that were published in English. Key search words included but were not limited to the following: *ad hoc angioplasty, angioplasty, balloon angioplasty, clinical trial, coronary stenting, delayed angioplasty, meta-analysis, percutaneous transluminal coronary angioplasty, randomized controlled trial, percutaneous coronary intervention (PCI) and angina, angina reduction, antiplatelet therapy, bare-metal stents (BMS), cardiac rehabilitation, chronic stable angina, complication, coronary bifurcation lesion, coronary calcified lesion, coronary chronic total occlusion, coronary ostial lesions, coronary stent (BMS and drug-eluting stents [DES]; and BMS versus DES), diabetes, distal embolization, distal protection, elderly, ethics, late stent thrombosis, medical therapy, microembolization, mortality, multiple lesions, multivessel, myocardial infarction, non-ST-elevation myocardial infarction (NSTEMI), no-reflow, optical coherence tomography, proton pump inhibitor, return to work, same-day angioplasty and/or stenting, slow flow, stable ischemic heart disease (SIHD), staged angioplasty, STEMI, survival, and unstable angina (UA)*. Additional searches cross-referenced these topics with the following subtopics: *anticoagulant therapy, contrast nephropathy, PCI-related vascular complications, unprotected left main PCI, multivessel coronary artery disease (CAD), adjunctive percutaneous interventional devices, percutaneous hemodynamic support devices, and secondary prevention*. Additionally, the committee reviewed documents related to the subject matter previously published by the ACCF and AHA. References selected and published in this document are representative and not all-inclusive.

Because the executive summary contains only the recommendations, the reader is encouraged to consult the full-text guideline (4) for additional detail on the recommendations and guidance on the care of the patient undergoing PCI.

### 1.2. Organization of the Writing Committee

The committee was composed of physicians with expertise in interventional cardiology, general cardiology, critical care cardiology, cardiothoracic surgery, clinical trials, and health services research. The committee included representatives from the ACCF, AHA, and SCAI.

### 1.3. Document Review and Approval

This document was reviewed by 2 official reviewers nominated by the ACCF, AHA, and SCAI, as well as 21 individual content reviewers (including members of the ACCF Interventional Scientific Council and ACCF Surgeons' Scientific Council). All information on reviewers' RWI was distributed to the writing committee and is published in this document (Appendix 2). This document was approved for publication by the governing bodies of the ACCF, AHA, and SCAI.

### 1.4. PCI Guideline Scope

The evolution of the PCI guideline reflects the growth of knowledge in the field and parallels the many advances and innovations in the field of interventional cardiology, including primary PCI, BMS and DES, intravascular ultrasound (IVUS) and physiologic assessments of stenosis, and newer antiplatelet and anticoagulant therapies. The 2011 iteration of the guideline continues this process, addressing ethical aspects of PCI, vascular access considerations, CAD revascularization including hybrid revascularization, revascularization before noncardiac surgery, optical coherence tomography, advanced hemodynamic support devices, no-reflow therapies, and vascular closure devices. Most of this document is organized according to "patient flow," consisting of preprocedural considerations, procedural considerations, and postprocedural considerations. The focus of this guideline is the safe, appropriate, and efficacious performance of PCI. The risks of PCI must be balanced against the likelihood of improved survival, symptoms, or functional status. This is especially important in patients with SIHD.

In a major undertaking, the STEMI, PCI, and coronary artery bypass graft (CABG) surgery guidelines were written concurrently, with additional collaboration with the SIHD guideline writing committee, allowing greater collaboration between the different writing committees on topics such as PCI in STEMI and revascularization strategies in patients with CAD (including unprotected left main PCI, multivessel disease revascularization, and hybrid procedures).

In accordance with direction from the Task Force and feedback from readers, in this iteration of the guideline, the text has been shortened, with an emphasis on summary statements rather than detailed discussion of numerous individual trials.

Online supplemental evidence and summary tables have been created to document the studies and data considered for new or changed guideline recommendations.

## 2. CAD Revascularization: Recommendations

Recommendations and text in this section are the result of extensive collaborative discussions between the PCI and CABG writing committees, as well as key members of the SIHD and UA/NSTEMI writing committees. Certain issues, such as older versus more contemporary studies, primary analyses versus subgroup analyses, and prospective versus post hoc analyses, have been carefully weighed in designating COR and LOE; they are addressed in the appropriate corresponding text (4). The goals of revascularization for patients with CAD are to 1) improve survival and/or 2) relieve symptoms. The following text contains recommendations for revascularization to improve survival and symptoms, and they are presented in Tables 2 and 3.

Revascularization recommendations in this section are predominantly based on studies of patients with symptomatic SIHD and should be interpreted in this context. As discussed later in this section, recommendations on the type of revascularization are, in general, applicable to patients with UA/NSTEMI. In some cases (e.g., unprotected left main CAD), specific recommendations are made for patients with UA/NSTEMI or STEMI.

### 2.1. Heart Team Approach to Revascularization Decisions

#### CLASS I

1. A Heart Team approach to revascularization is recommended in patients with unprotected left main or complex CAD (5–7). (Level of Evidence: C)

#### CLASS IIa

1. Calculation of the Society of Thoracic Surgeons and SYNTAX (Synergy between Percutaneous Coronary Intervention with TAXUS and Cardiac Surgery) scores is reasonable in patients with unprotected left main and complex CAD (7–14). (Level of Evidence: B)

### 2.2. Revascularization to Improve Survival

#### Left Main CAD Revascularization

#### CLASS I

1. CABG to improve survival is recommended for patients with significant ( $\geq 50\%$  diameter stenosis) left main coronary artery stenosis (15–21). (Level of Evidence: B)

#### CLASS IIa

1. PCI to improve survival is reasonable as an alternative to CABG in selected stable patients with significant ( $\geq 50\%$  diameter stenosis) unprotected left main CAD with: 1) anatomic conditions associated with a low risk of PCI procedural complications and a high likelihood of good long-term outcome (e.g., a low SYNTAX score [ $\leq 22$ ], ostial or trunk left main CAD); and 2) clinical characteristics that predict a significantly increased risk of adverse surgical outcomes (e.g., Society of Thoracic Surgeons–predicted risk of operative mortality  $\geq 5\%$ ) (8,10,11,22–40,106) (Level of Evidence: B)

2. PCI to improve survival is reasonable in patients with UA/NSTEMI when an unprotected left main coronary artery is the culprit lesion and the patient is not a candidate for CABG (11,27,29–31,36,37,39–41). (Level of Evidence: B)
3. PCI to improve survival is reasonable in patients with acute STEMI when an unprotected left main coronary artery is the culprit lesion, distal coronary flow is less than TIMI (Thrombolysis In Myocardial Infarction) grade 3, and PCI can be performed more rapidly and safely than CABG (24,42,43). (Level of Evidence: C)

#### CLASS IIb

1. PCI to improve survival may be reasonable as an alternative to CABG in selected stable patients with significant ( $\geq 50\%$  diameter stenosis) unprotected left main CAD with: 1) anatomic conditions associated with a low to intermediate risk of PCI procedural complications and an intermediate to high likelihood of good long-term outcome (e.g., low-intermediate SYNTAX score of  $< 33$ , bifurcation left main CAD); and 2) clinical characteristics that predict an increased risk of adverse surgical outcomes (e.g., moderate-severe chronic obstructive pulmonary disease, disability from previous stroke, or previous cardiac surgery; Society of Thoracic Surgeons–predicted risk of operative mortality  $> 2\%$ ) (8,10,11,22–40,44). (Level of Evidence: B)

#### CLASS III: HARM

1. PCI to improve survival should not be performed in stable patients with significant ( $\geq 50\%$  diameter stenosis) unprotected left main CAD who have unfavorable anatomy for PCI and who are good candidates for CABG (8,10,11,15–23). (Level of Evidence: B)

### Non-Left Main CAD Revascularization

#### CLASS I

1. CABG to improve survival is beneficial in patients with significant ( $\geq 70\%$  diameter) stenoses in 3 major coronary arteries (with or without involvement of the proximal left anterior descending [LAD]) or in the proximal LAD plus 1 other major coronary artery (17,21,45–48). (Level of Evidence: B)
2. CABG or PCI to improve survival is beneficial in survivors of sudden cardiac death with presumed ischemia-mediated ventricular tachycardia caused by significant ( $\geq 70\%$  diameter) stenosis in a major coronary artery. (CABG Level of Evidence: B [49–51]; PCI Level of Evidence: C [49])

#### CLASS IIa

1. CABG to improve survival is reasonable in patients with significant ( $\geq 70\%$  diameter) stenoses in 2 major coronary arteries with severe or extensive myocardial ischemia (e.g., high-risk criteria on stress testing, abnormal intracoronary hemodynamic evaluation, or  $> 20\%$  perfusion defect by myocardial perfusion stress imaging) or target vessels supplying a large area of viable myocardium (52–55). (Level of Evidence: B)
2. CABG to improve survival is reasonable in patients with mild-moderate left ventricular systolic dysfunction (ejection fraction 35% to 50%) and significant ( $\geq 70\%$  diameter stenosis) multivessel CAD or proximal LAD coronary artery stenosis, when viable myocardium is present in the region of intended revascularization (21,56–60). (Level of Evidence: B)
3. CABG with a left internal mammary artery graft to improve survival is reasonable in patients with significant ( $\geq 70\%$  diameter) stenosis in the proximal LAD artery and evidence of extensive ischemia (21,48,61,62). (Level of Evidence: B)

**Table 2. Revascularization to Improve Survival Compared With Medical Therapy**

Anatomic Setting	COR	LOE	References
<b>UPLM or complex CAD</b>			
<b>CABG and PCI</b>	I—Heart Team approach recommended	C	(5–7)
<b>CABG and PCI</b>	Ila—Calculation of STS and SYNTAX scores	B	(7–14)
<b>UPLM*</b>			
<b>CABG</b>	I	B	(15–21)
<b>PCI</b>	Ila—For SIHD when <i>both</i> of the following are present: • Anatomic conditions associated with a low risk of PCI procedural complications and a high likelihood of good long-term outcome (e.g., a low SYNTAX score of $\leq 22$ , ostial or trunk left main CAD) • Clinical characteristics that predict a significantly increased risk of adverse surgical outcomes (e.g., STS-predicted risk of operative mortality $\geq 5\%$ )	B	(8,10,11,22–40,106)
	Ila—For UA/NSTEMI if not a CABG candidate	B	(11,27,29–31,36,37,39–41)
	Ila—For STEMI when distal coronary flow is TIMI flow grade $< 3$ and PCI can be performed more rapidly and safely than CABG	C	(24,42,43)
	Ilb—For SIHD when <i>both</i> of the following are present: • Anatomic conditions associated with a low to intermediate risk of PCI procedural complications and an intermediate to high likelihood of good long-term outcome (e.g. low-intermediate SYNTAX score of $< 33$ , bifurcation left main CAD) • Clinical characteristics that predict an increased risk of adverse surgical outcomes (e.g., moderate-severe COPD, disability from prior stroke, or prior cardiac surgery; STS-predicted risk of operative mortality $> 2\%$ )	B	(8,10,11,22–40,44)
	III: Harm—For SIHD in patients (versus performing CABG) with unfavorable anatomy for PCI and who are good candidates for CABG	B	(8,10,11,15–23)
<b>3-vessel disease with or without proximal LAD artery disease*</b>			
<b>CABG</b>	I	B	(17,21,45–48)
	Ila—It is reasonable to choose CABG over PCI in patients with complex 3-vessel CAD (e.g., SYNTAX score $> 22$ ) who are good candidates for CABG.	B	(23,38,48,63,64)
<b>PCI</b>	Ilb—Of uncertain benefit	B	(17,45,48,74)
<b>2-vessel disease with proximal LAD artery disease*</b>			
<b>CABG</b>	I	B	(17,21,45–48)
<b>PCI</b>	Ilb—Of uncertain benefit	B	(17,45,48,74)
<b>2-vessel disease without proximal LAD artery disease*</b>			
<b>CABG</b>	Ila—With extensive ischemia	B	(52–55)
	Ilb—Of uncertain benefit without extensive ischemia	C	(48)
<b>PCI</b>	Ilb—Of uncertain benefit	B	(17,45,48,74)
<b>1-vessel proximal LAD artery disease</b>			
<b>CABG</b>	Ila—With LIMA for long-term benefit	B	(21,48,61,62)
<b>PCI</b>	Ilb—Of uncertain benefit	B	(17,45,48,74)
<b>1-vessel disease without proximal LAD artery involvement</b>			
<b>CABG</b>	III: Harm	B	(21,45,52,53,86–90)
<b>PCI</b>	III: Harm	B	(21,45,52,53,86–90)
<b>LV dysfunction</b>			
<b>CABG</b>	Ila—EF 35% to 50%	B	(21,56–60)
<b>CABG</b>	Ilb—EF $< 35\%$ without significant left main CAD	B	(21,56–60,75,76)
<b>PCI</b>	Insufficient data		N/A
<b>Survivors of sudden cardiac death with presumed ischemia-mediated VT</b>			
<b>CABG</b>	I	B	(49–51)
<b>PCI</b>	I	C	(49)
<b>No anatomic or physiologic criteria for revascularization</b>			
<b>CABG</b>	III: Harm	B	(21,45,52,53,86–90)
<b>PCI</b>	III: Harm	B	(21,45,52,53,86–90)

\*In patients with multivessel disease who also have diabetes, it is reasonable to choose CABG (with LIMA) over PCI (54,66–73) (Class Ila; LOE: B).

CABG indicates coronary artery bypass graft; CAD, coronary artery disease; COPD, chronic obstructive pulmonary disease; COR, class of recommendation; EF, ejection fraction; LAD, left anterior descending; LIMA, left internal mammary artery; LOE, level of evidence; LV, left ventricular; N/A, not applicable; PCI, percutaneous coronary intervention; SIHD, stable ischemic heart disease; STEMI, ST-elevation myocardial infarction; STS, Society of Thoracic Surgeons; SYNTAX, Synergy Between Percutaneous Coronary Intervention With Taxus and Cardiac Surgery; TIMI, Thrombolysis In Myocardial Infarction; UA/NSTEMI, unstable angina/non-ST-elevation myocardial infarction; UPLM, unprotected left main disease; and VT, ventricular tachycardia.

**Table 3. Revascularization to Improve Symptoms With Significant Anatomic ( $\geq 50\%$  Left Main or  $\geq 70\%$  Non-Left Main CAD) or Physiological (FFR $\leq 0.80$ ) Coronary Artery Stenoses**

Clinical Setting	COR	LOE	References
$\geq 1$ significant stenoses amenable to revascularization and unacceptable angina despite GDMT	I – CABG I – PCI	A	(74,91–100)
$\geq 1$ significant stenoses and unacceptable angina in whom GDMT cannot be implemented because of medication contraindications, adverse effects, or patient preferences	IIa – CABG IIa – PCI	C	N/A
Previous CABG with $\geq 1$ significant stenoses associated with ischemia and unacceptable angina despite GDMT	IIa – PCI	C	(78,81,84)
	IIb – CABG	C	(85)
Complex 3-vessel CAD (e.g., SYNTAX score $>22$ ) with or without involvement of the proximal LAD artery and a good candidate for CABG	IIa – CABG preferred over PCI	B	(23,38,48,63,64)
Viable ischemic myocardium that is perfused by coronary arteries that are not amenable to grafting	IIb – TMR as an adjunct to CABG	B	(101–105)
No anatomic or physiologic criteria for revascularization	III: Harm – CABG III: Harm – PCI	C	N/A

CABG indicates coronary artery bypass graft; CAD, coronary artery disease; COR, class of recommendation; FFR, fractional flow reserve; GDMT, guideline-directed medical therapy; LOE, level of evidence; N/A, not applicable; PCI, percutaneous coronary intervention; SYNTAX, Synergy between Percutaneous Coronary Intervention with TAXUS and Cardiac Surgery; and TMR, transmyocardial laser revascularization.

- It is reasonable to choose CABG over PCI to improve survival in patients with complex 3-vessel CAD (e.g., SYNTAX score  $>22$ ) with or without involvement of the proximal LAD artery who are good candidates for CABG (23,38,48,63,64). (Level of Evidence: B)
- CABG is probably recommended in preference to PCI to improve survival in patients with multivessel CAD and diabetes mellitus, particularly if a left internal mammary artery graft can be anastomosed to the LAD artery (54,66–73). (Level of Evidence: B)

#### CLASS IIb

- The usefulness of CABG to improve survival is uncertain in patients with significant ( $\geq 70\%$ ) stenoses in 2 major coronary arteries not involving the proximal LAD artery and without extensive ischemia (48). (Level of Evidence: C)
- The usefulness of PCI to improve survival is uncertain in patients with 2- or 3-vessel CAD (with or without involvement of the proximal LAD artery) or 1-vessel proximal LAD disease (17,45,48,74). (Level of Evidence: B)
- CABG might be considered with the primary or sole intent of improving survival in patients with SIHD with severe left ventricular systolic dysfunction (ejection fraction  $<35\%$ ) whether or not viable myocardium is present (21,56–60,75,76). (Level of Evidence: B)
- The usefulness of CABG or PCI to improve survival is uncertain in patients with previous CABG and extensive anterior wall ischemia on noninvasive testing (77–85). (Level of Evidence: B)

#### CLASS III: HARM

- CABG or PCI should not be performed with the primary or sole intent to improve survival in patients with SIHD with 1 or more coronary stenoses that are not anatomically or functionally significant (e.g.,  $<70\%$  diameter non-left main coronary artery stenosis, fractional flow reserve  $>0.80$ , no or only mild ischemia on noninvasive testing), involve only the left circumflex or right coronary artery, or subtend only a small area of viable myocardium (21,45,52,53,86–90). (Level of Evidence: B)

### 2.3. Revascularization to Improve Symptoms

#### CLASS I

- CABG or PCI to improve symptoms is beneficial in patients with 1 or more significant ( $\geq 70\%$  diameter) coronary artery stenoses amenable to revascularization and unacceptable angina despite GDMT (74,91–100). (Level of Evidence: A)

#### CLASS IIa

- CABG or PCI to improve symptoms is reasonable in patients with 1 or more significant ( $\geq 70\%$  diameter) coronary artery stenoses and unacceptable angina for whom GDMT cannot be implemented because of medication contraindications, adverse effects, or patient preferences. (Level of Evidence: C)
- PCI to improve symptoms is reasonable in patients with previous CABG, 1 or more significant ( $\geq 70\%$  diameter) coronary artery stenoses associated with ischemia, and unacceptable angina despite GDMT (78,81,84). (Level of Evidence: C)
- It is reasonable to choose CABG over PCI to improve symptoms in patients with complex 3-vessel CAD (e.g., SYNTAX score  $>22$ ), with or without involvement of the proximal LAD artery who are good candidates for CABG (23,38,48,63,64). (Level of Evidence: B)

#### CLASS IIb

- CABG to improve symptoms might be reasonable for patients with previous CABG, 1 or more significant ( $\geq 70\%$  diameter) coronary artery stenoses not amenable to PCI, and unacceptable angina despite GDMT (85). (Level of Evidence: C)
- Transmyocardial laser revascularization performed as an adjunct to CABG to improve symptoms may be reasonable in patients with viable ischemic myocardium that is perfused by arteries that are not amenable to grafting (101–105). (Level of Evidence: B)

#### CLASS III: HARM

- CABG or PCI to improve symptoms should not be performed in patients who do not meet anatomic ( $\geq 50\%$  left main or  $\geq 70\%$  non-left main stenosis) or physiological (e.g., abnormal fractional flow reserve) criteria for revascularization. (Level of Evidence: C)

### 2.4. Clinical Factors That May Influence the Choice of Revascularization

#### 2.4.1. Dual Antiplatelet Therapy Compliance and Stent Thrombosis

#### CLASS III: HARM

- PCI with coronary stenting (BMS or DES) should not be performed if the patient is not likely to be able to tolerate and comply with dual antiplatelet therapy (DAPT) for the appropriate duration of treatment based on the type of stent implanted (107–110). (Level of Evidence: B)



**Table 4. Summary of Recommendations for Preprocedural Considerations and Interventions in Patients Undergoing PCI**

Recommendations	COR	LOE	References
Contrast-induced AKI			
Patients should be assessed for risk of contrast-induced AKI before PCI.	I	C	(118,119)
Patients undergoing cardiac catheterization with contrast media should receive adequate preparatory hydration.	I	B	(120–123)
In patients with CKD (creatinine clearance <60 mL/min), the volume of contrast media should be minimized.	I	B	(124–126)
Administration of N-acetyl-L-cysteine is not useful for the prevention of contrast-induced AKI.	III: No Benefit	A	(127–131)
Anaphylactoid reactions			
Patients with prior evidence of an anaphylactoid reaction to contrast media should receive appropriate prophylaxis before repeat contrast administration.	I	B	(132–135)
In patients with a prior history of allergic reactions to shellfish or seafood, anaphylactoid prophylaxis for contrast reaction is not beneficial.	III: No Benefit	C	(136–138)
Statins			
Administration of a high-dose statin is reasonable before PCI to reduce the risk of periprocedural MI.	IIa	A: Statin naïve	(139–145)
		B: Chronic statin therapy	(146)
Bleeding risk			
All patients should be evaluated for risk of bleeding before PCI.	I	C	N/A
CKD			
In patients undergoing PCI, the glomerular filtration rate should be estimated and the dosage of renally cleared medications should be adjusted.	I	B	(147–149)
Aspirin			
Patients already on daily aspirin therapy should take 81 mg to 325 mg before PCI.	I	B	(150–153)
Patients not on aspirin therapy should be given nonenteric aspirin 325 mg before PCI.	I	B	(150,152,153)

AKI indicates acute kidney injury; CKD, chronic kidney disease; COR, class of recommendation; LOE, level of evidence; MI, myocardial infarction; N/A, not applicable; and PCI, percutaneous coronary intervention.

## 2.5. Hybrid Coronary Revascularization

### CLASS IIa

- Hybrid coronary revascularization (defined as the planned combination of left internal mammary artery-to-LAD artery grafting and PCI of  $\geq 1$  non-LAD coronary arteries) is reasonable in patients with 1 or more of the following (111–117) (Level of Evidence: B):
  - Limitations to traditional CABG, such as heavily calcified proximal aorta or poor target vessels for CABG (but amenable to PCI);
  - Lack of suitable graft conduits;
  - Unfavorable LAD artery or PCI (i.e., excessive vessel tortuosity or chronic total occlusion).

### CLASS IIb

- Hybrid coronary revascularization (defined as the planned combination of left internal mammary artery-to-LAD artery grafting and PCI of  $\geq 1$  non-LAD coronary arteries) may be reasonable as an alternative to multivessel PCI or CABG in an attempt to improve the overall risk-benefit ratio of the procedures. (Level of Evidence: C)

## 3. Preprocedural Considerations: Recommendations

Table 4 contains recommendations for preprocedural considerations and interventions in patients undergoing PCI.

### 3.1. Radiation Safety

#### CLASS I

- Cardiac catheterization laboratories should routinely record relevant available patient procedural radiation dose data (e.g., total air

kerma at the international reference point [ $K_{a,r}$ ], air kerma air product [ $P_{KA}$ ], fluoroscopy time, number of cine images), and should define thresholds with corresponding follow-up protocols for patients who receive a high procedural radiation dose. (Level of Evidence: C)

### 3.2. Contrast-Induced Acute Kidney Injury

#### CLASS I

- Patients should be assessed for risk of contrast-induced acute kidney injury before PCI (118,119). (Level of Evidence: C)
- Patients undergoing cardiac catheterization with contrast media should receive adequate preparatory hydration (120–123). (Level of Evidence: B)
- In patients with CKD (creatinine clearance <60 mL/min), the volume of contrast media should be minimized (124–126). (Level of Evidence: B)

#### CLASS III: NO BENEFIT

- Administration of N-acetyl-L-cysteine is not useful for the prevention of contrast-induced acute kidney injury (127–131). (Level of Evidence: A)

### 3.3. Anaphylactoid Reactions

#### CLASS I

- Patients with prior evidence of an anaphylactoid reaction to contrast media should receive appropriate steroid and antihistamine prophylaxis before repeat contrast administration (132–135). (Level of Evidence: B)

**Table 5. Indications for Coronary Angiography in STEMI**

Indications	COR	LOE	References
<b>Immediate coronary angiography</b>			
Candidate for primary PCI	I	A	(155,175–178)
Severe heart failure or cardiogenic shock (if suitable revascularization candidate)	I	B	(179,180)
Moderate to large area of myocardium at risk and evidence of failed fibrinolysis	Ila	B	(181,182)
<b>Coronary angiography 3 to 24 h after fibrinolysis</b>			
Hemodynamically stable patients with evidence for successful fibrinolysis	Ila	A	(183–187)
<b>Coronary angiography before hospital discharge</b>			
Stable patients	Ilb	C	N/A
<b>Coronary angiography at any time</b>			
Patients in whom the risks of revascularization are likely to outweigh the benefits or the patient or designee does not want invasive care	III: No Benefit	C	N/A

COR indicates class of recommendation; LOE, level of evidence; N/A, not applicable; PCI, percutaneous coronary intervention; and STEMI; ST-elevation myocardial infarction.

**CLASS III: NO BENEFIT**

1. In patients with a prior history of allergic reactions to shellfish or seafood, anaphylactoid prophylaxis for contrast reaction is not beneficial (136–138). (Level of Evidence: C)

**3.4. Statin Treatment**

**CLASS Ila**

1. Administration of a high-dose statin is reasonable before PCI to reduce the risk of periprocedural myocardial infarction. (Level of Evidence: A for statin-naïve patients [139–145]; Level of Evidence: B for those on chronic statin therapy [146])

**3.5. Bleeding Risk**

**CLASS I**

1. All patients should be evaluated for risk of bleeding before PCI. (Level of Evidence: C)

**3.6. PCI in Hospitals Without On-Site Surgical Backup**

**CLASS Ila**

1. Primary PCI is reasonable in hospitals without on-site cardiac surgery, provided that appropriate planning for program development has been accomplished (155,156). (Level of Evidence: B)

**CLASS Iib**

1. Elective PCI might be considered in hospitals without on-site cardiac surgery, provided that appropriate planning for program development has been accomplished and rigorous clinical and angiographic criteria are used for proper patient selection (156–158). (Level of Evidence: B)

**CLASS III: HARM**

1. Primary or elective PCI should not be performed in hospitals without on-site cardiac surgery capabilities without a proven plan for rapid transport to a cardiac surgery operating room in a nearby hospital or without appropriate hemodynamic support capability for transfer. (Level of Evidence: C)

**4. Procedural Considerations: Recommendations**

**4.1. Vascular Access**

**CLASS Ila**

1. The use of radial artery access can be useful to decrease access site complications (159–167). (Level of Evidence: A)

**4.2. PCI in Specific Clinical Situations**

**4.2.1. Unstable Angina/Non-ST-Elevation Myocardial Infarction**

**CLASS I**

1. An early invasive strategy (i.e., diagnostic angiography with intent to perform revascularization) is indicated in UA/NSTEMI patients who have refractory angina or hemodynamic or electrical instability (without serious comorbidities or contraindications to such procedures) (168–170). (Level of Evidence: B)
2. An early invasive strategy (i.e., diagnostic angiography with intent to perform revascularization) is indicated in initially stabilized UA/NSTEMI patients (without serious comorbidities or contraindications to such procedures) who have an elevated risk for clinical events (169–172). (Level of Evidence: A)
3. The selection of PCI or CABG as the means of revascularization in the patient with acute coronary syndrome (ACS) should generally be based on the same considerations as those without ACS (45,170,173,174). (Level of Evidence: B)

**CLASS III: NO BENEFIT**

1. An early invasive strategy (i.e., diagnostic angiography with intent to perform revascularization) is not recommended in patients with extensive comorbidities (e.g., liver or pulmonary failure, cancer) in whom (Level of Evidence: C)
  - a. The risks of revascularization and comorbid conditions are likely to outweigh the benefits of revascularization,
  - b. There is a low likelihood of ACS despite acute chest pain, or
  - c. Consent to revascularization will not be granted regardless of the findings.

**4.2.2. ST-Elevation Myocardial Infarction**

Table 5 contains indications for coronary angiography in STEMI.

**4.2.2.1. CORONARY ANGIOGRAPHY STRATEGIES IN STEMI**

**CLASS I**

1. A strategy of immediate coronary angiography with intent to perform PCI (or emergency CABG) in patients with STEMI is recommended for:
  - a. Patients who are candidates for primary PCI (155,175–178). (Level of Evidence: A)

- b. Patients with severe heart failure or cardiogenic shock who are suitable candidates for revascularization (179,180). (Level of Evidence: B)

#### CLASS IIa

1. A strategy of immediate coronary angiography (or transfer for immediate coronary angiography) with intent to perform PCI is reasonable for patients with STEMI, a moderate to large area of myocardium at risk, and evidence of failed fibrinolysis (181,182). (Level of Evidence: B)
2. A strategy of coronary angiography (or transfer for coronary angiography) 3 to 24 hours after initiating fibrinolytic therapy with intent to perform PCI is reasonable for hemodynamically stable patients with STEMI and evidence for successful fibrinolysis when angiography and revascularization can be performed as soon as logistically feasible in this time frame (183–187). (Level of Evidence: A)

#### CLASS IIb

1. A strategy of coronary angiography performed before hospital discharge might be reasonable in stable patients with STEMI who did not undergo cardiac catheterization within 24 hours of STEMI onset. (Level of Evidence: C)

#### CLASS III: NO BENEFIT

1. A strategy of coronary angiography with intent to perform PCI is not recommended in patients with STEMI in whom the risks of revascularization are likely to outweigh the benefits or when the patient or designee does not want invasive care. (Level of Evidence: C)

#### 4.2.2.2. PRIMARY PCI OF THE INFARCT ARTERY

#### CLASS I

1. Primary PCI should be performed in patients within 12 hours of onset of STEMI (175–178). (Level of Evidence: A)
2. Primary PCI should be performed in patients with STEMI presenting to a hospital with PCI capability within 90 minutes of first medical contact as a systems goal (188,189). (Level of Evidence: B)
3. Primary PCI should be performed in patients with STEMI presenting to a hospital without PCI capability within 120 minutes of first medical contact as a systems goal (190–192). (Level of Evidence: B)
4. Primary PCI should be performed in patients with STEMI who develop severe heart failure or cardiogenic shock and are suitable candidates for revascularization as soon as possible, irrespective of time delay (179,180). (Level of Evidence: B)
5. Primary PCI should be performed as soon as possible in patients with STEMI and contraindications to fibrinolytic therapy with ischemic symptoms for less than 12 hours (193,194). (Level of Evidence: B)

#### CLASS IIa

1. Primary PCI is reasonable in patients with STEMI if there is clinical and/or electrocardiographic evidence of ongoing ischemia between 12 and 24 hours after symptom onset (195–197). (Level of Evidence: B)

#### CLASS IIb

1. Primary PCI might be considered in asymptomatic patients with STEMI and higher risk presenting between 12 and 24 hours after symptom onset. (Level of Evidence: C)

#### CLASS III: HARM

1. PCI should not be performed in a noninfarct artery at the time of primary PCI in patients with STEMI without hemodynamic compromise (198–202). (Level of Evidence: B)

#### 4.2.2.3. DELAYED OR ELECTIVE PCI IN PATIENTS WITH STEMI

#### CLASS IIa

1. PCI is reasonable in patients with STEMI and clinical evidence for fibrinolytic failure or infarct artery reocclusion (181,182). (Level of Evidence: B)
2. PCI is reasonable in patients with STEMI and a patent infarct artery 3 to 24 hours after fibrinolytic therapy (186,187). (Level of Evidence: B)
3. PCI is reasonable in patients with STEMI who demonstrate ischemia on noninvasive testing (203,204). (Level of Evidence: B)

#### CLASS IIb

1. PCI of a hemodynamically significant stenosis in a patent infarct artery greater than 24 hours after STEMI may be considered as part of an invasive strategy (205–209). (Level of Evidence: B)

#### CLASS III: NO BENEFIT

1. PCI of a totally occluded infarct artery greater than 24 hours after STEMI should not be performed in asymptomatic patients with 1- or 2-vessel disease if patients are hemodynamically and electrically stable and do not have evidence of severe ischemia (210–212). (Level of Evidence: B)

Table 6 contains indications for PCI in STEMI.

#### 4.2.3. Cardiogenic Shock

#### CLASS I

1. PCI is recommended for patients with acute myocardial infarction who develop cardiogenic shock and are suitable candidates (180,213–215). (Level of Evidence: B)
2. A hemodynamic support device is recommended for patients with cardiogenic shock after STEMI who do not quickly stabilize with pharmacological therapy (180,216–219). (Level of Evidence: B)

#### 4.2.4. Revascularization Before Noncardiac Surgery

#### CLASS IIa

1. For patients who require PCI and are scheduled for elective noncardiac surgery in the subsequent 12 months, a strategy of balloon angioplasty, or BMS implantation followed by 4 to 6 weeks of DAPT, is reasonable (220–226). (Level of Evidence: B)
2. For patients with DES who must undergo urgent surgical procedures that mandate the discontinuation of DAPT, it is reasonable to continue aspirin if possible and restart the P2Y<sub>12</sub> inhibitor as soon as possible in the immediate postoperative period (222,227). (Level of Evidence: C)

#### CLASS III: HARM

1. Routine prophylactic coronary revascularization should not be performed in patients with stable CAD before noncardiac surgery (228,229). (Level of Evidence: B)
2. Elective noncardiac surgery should not be performed in the 4 to 6 weeks after balloon angioplasty or BMS implantation or the 12 months after DES implantation in patients in whom the P2Y<sub>12</sub> inhibitor will need to be discontinued perioperatively (107,225, 230,231). (Level of Evidence: B)

**Table 6. Indications for PCI in STEMI**

Indications	COR	LOE	References
<b>Primary PCI*</b>			
STEMI symptoms within 12 h	I	A	(175–178)
Severe heart failure or cardiogenic shock	I	B	(179,180)
Contraindications to fibrinolytic therapy with ischemic symptoms <12 h	I	B	(193,194)
Clinical and/or electrocardiographic evidence of ongoing ischemia between 12 and 24 h after symptom onset	IIa	B	(195–197)
Asymptomatic patients presenting between 12 and 24 h after symptom onset and higher risk	IIb	C	N/A
Noninfarct artery PCI at the time of primary PCI in patients without hemodynamic compromise	III: Harm	B	(198–202)
<b>Delayed or elective PCI in patients with STEMI</b>			
Clinical evidence for fibrinolytic failure or infarct artery reocclusion	IIa	B	(181,182)
Patent infarct artery 3 to 24 h after fibrinolytic therapy	IIa	B	(186,187)
Ischemia on noninvasive testing	IIa	B	(203,204)
Hemodynamically significant stenosis in a patent infarct artery >24 h after STEMI	IIb	B	(205–209)
Totally occluded infarct artery >24 h after STEMI in a hemodynamically stable asymptomatic patient without evidence of severe ischemia	III: No Benefit	B	(210–212)

\*Systems goal of performing primary PCI within 90 min of first medical contact when the patient presents to a hospital with PCI capability (188,189) (Class I; LOE: B) and within 120 min when the patient presents to a hospital without PCI capability (190–192) (Class I; LOE: B).

COR indicates class of recommendation; LOE, level of evidence; N/A, not applicable; PCI, percutaneous coronary intervention; and STEMI, ST-elevation myocardial infarction.

### 4.3. Coronary Stents

#### CLASS I

- Before implantation of DES, the interventional cardiologist should discuss with the patient the need for and duration of DAPT and the ability of the patient to comply with and tolerate DAPT (232). (Level of Evidence: C)
- DES are useful as an alternative to BMS to reduce the risk of restenosis in cases in which the risk of restenosis is increased and the patient is likely to be able to tolerate and comply with prolonged DAPT (Level of Evidence: A for elective PCI [233–237]; Level of Evidence: C for UA/NSTEMI [235]; Level of Evidence: A for STEMI [235,236,238–240]).
- Balloon angioplasty or BMS should be used in patients with high bleeding risk, inability to comply with 12 months of DAPT, or anticipated invasive or surgical procedures within the next 12 months, during which time DAPT may be interrupted (107,241–243). (Level of Evidence: B)

#### CLASS III: HARM

- PCI with coronary stenting should not be performed if the patient is not likely to be able to tolerate and comply with DAPT (107–110). (Level of Evidence: B)
- DES should not be implanted if the patient is not likely to be able to tolerate and comply with prolonged DAPT or this cannot be determined before stent implantation (107,241–243). (Level of Evidence: B)

### 4.4. Adjunctive Diagnostic Devices

#### 4.4.1. Fractional Flow Reserve

##### CLASS IIa

- Fractional flow reserve is reasonable to assess angiographic intermediate coronary lesions (50% to 70% diameter stenosis) and can be useful for guiding revascularization decisions in patients with SIHD (89,244–247). (Level of Evidence: A)

#### 4.4.2. Intravascular Ultrasound

##### CLASS IIa

- IVUS is reasonable for the assessment of angiographically indeterminate left main CAD (248–250). (Level of Evidence: B)
- IVUS and coronary angiography are reasonable 4 to 6 weeks and 1 year after cardiac transplantation to exclude donor CAD, detect rapidly progressive cardiac allograft vasculopathy, and provide prognostic information (251–253). (Level of Evidence: B)
- IVUS is reasonable to determine the mechanism of stent restenosis (254). (Level of Evidence: C)

##### CLASS IIb

- IVUS may be reasonable for the assessment of non-left main coronary arteries with angiographically intermediate coronary stenoses (50% to 70% diameter stenosis) (248,255,256). (Level of Evidence: B)
- IVUS may be considered for guidance of coronary stent implantation, particularly in cases of left main coronary artery stenting (249,254,257). (Level of Evidence: B)
- IVUS may be reasonable to determine the mechanism of stent thrombosis (254). (Level of Evidence: C)

##### CLASS III: NO BENEFIT

- IVUS for routine lesion assessment is not recommended when revascularization with PCI or CABG is not being contemplated. (Level of Evidence: C)

### 4.5. Adjunctive Therapeutic Devices

#### 4.5.1. Coronary Atherectomy

##### CLASS IIa

- Rotational atherectomy is reasonable for fibrotic or heavily calcified lesions that might not be crossed by a balloon catheter or adequately dilated before stent implantation (258,259). (Level of Evidence: C)

##### CLASS III: NO BENEFIT

- Rotational atherectomy should not be performed routinely for de novo lesions or in-stent restenosis (260–263). (Level of Evidence: A)



#### 4.5.2. Thrombectomy

##### CLASS IIa

1. Aspiration thrombectomy is reasonable for patients undergoing primary PCI (264–266). (Level of Evidence: B)

#### 4.5.3. Laser Angioplasty

##### CLASS IIb

1. Laser angioplasty might be considered for fibrotic or moderately calcified lesions that cannot be crossed or dilated with conventional balloon angioplasty (267). (Level of Evidence: C)

##### CLASS III: NO BENEFIT

1. Laser angioplasty should not be used routinely during PCI (260,262,268). (Level of Evidence: A)

#### 4.5.4. Cutting Balloon Angioplasty

##### CLASS IIb

1. Cutting balloon angioplasty might be considered to avoid slippage-induced coronary artery trauma during PCI for in-stent restenosis or ostial lesions in side branches (269). (Level of Evidence: C)

##### CLASS III: NO BENEFIT

1. Cutting balloon angioplasty should not be performed routinely during PCI (260,269,270). (Level of Evidence: A)

#### 4.5.5. Embolic Protection Devices

##### CLASS I

1. Embolic protection devices should be used during saphenous vein graft PCI when technically feasible (271–274). (Level of Evidence: B)

#### 4.6. Percutaneous Hemodynamic Support Devices

Table 7 contains recommendations for antiplatelet and antithrombin pharmacotherapy at the time of PCI.

##### CLASS IIb

1. Elective insertion of an appropriate hemodynamic support device as an adjunct to PCI may be reasonable in carefully selected high-risk patients. (Level of Evidence: C)

#### 4.6.1. Oral Antiplatelet Therapy

##### CLASS I

1. Patients already taking daily aspirin therapy should take 81 mg to 325 mg before PCI (150–153). (Level of Evidence: B)
2. Patients not on aspirin therapy should be given nonenteric aspirin 325 mg before PCI (150,152,153). (Level of Evidence: B)
3. After PCI, use of aspirin should be continued indefinitely (275–278). (Level of Evidence: A)
4. A loading dose of a P2Y<sub>12</sub> receptor inhibitor should be given to patients undergoing PCI with stenting (279–283) (Level of Evidence: A). Options include
  - a. Clopidogrel 600 mg (ACS and non-ACS patients) (279–281). (Level of Evidence: B)
  - b. Prasugrel 60 mg (ACS patients) (282). (Level of Evidence: B)
  - c. Ticagrelor 180 mg (ACS patients) (283). (Level of Evidence: B)
5. The loading dose of clopidogrel for patients undergoing PCI after fibrinolytic therapy should be 300 mg within 24 hours and 600 mg more than 24 hours after receiving fibrinolytic therapy (280,284). (Level of Evidence: C)
6. Patients should be counseled on the need for and risks of DAPT before placement of intracoronary stents, especially DES, and alter-

native therapies should be pursued if patients are unwilling or unable to comply with the recommended duration of DAPT (107). (Level of Evidence: C)

7. The duration of P2Y<sub>12</sub> inhibitor therapy after stent implantation should generally be as follows:

- a. In patients receiving a stent (BMS or DES) during PCI for ACS, P2Y<sub>12</sub> inhibitor therapy should be given for at least 12 months. Options include clopidogrel 75 mg daily (285), prasugrel 10 mg daily (282), and ticagrelor 90 mg twice daily (283). (Level of Evidence: B)
- b. In patients receiving DES for a non-ACS indication, clopidogrel 75 mg daily should be given for at least 12 months if patients are not at high risk of bleeding (107,232,286). (Level of Evidence: B)
- c. In patients receiving BMS for a non-ACS indication, clopidogrel should be given for a minimum of 1 month and ideally up to 12 months (unless the patient is at increased risk of bleeding; then it should be given for a minimum of 2 weeks) (107,287). (Level of Evidence: B)

##### CLASS IIa

1. After PCI, it is reasonable to use aspirin 81 mg per day in preference to higher maintenance doses (151,288–291). (Level of Evidence: B)
2. If the risk of morbidity from bleeding outweighs the anticipated benefit afforded by a recommended duration of P2Y<sub>12</sub> inhibitor therapy after stent implantation, earlier discontinuation (e.g., <12 months) of P2Y<sub>12</sub> inhibitor therapy is reasonable. (Level of Evidence: C)

##### CLASS IIb

1. Continuation of DAPT beyond 12 months may be considered in patients undergoing DES implantation (282,283). (Level of Evidence: C)

##### CLASS III: HARM

1. Prasugrel should not be administered to patients with a prior history of stroke or transient ischemic attack (282). (Level of Evidence: B)

#### 4.6.2. Intravenous Antiplatelet Therapy

##### STEMI

##### CLASS IIa

1. In patients undergoing primary PCI treated with unfractionated heparin (UFH), it is reasonable to administer a glycoprotein (GP) IIb/IIIa inhibitor (abciximab, double-bolus eptifibatide, or high-bolus dose tirofiban), whether or not patients were pretreated with clopidogrel (292–298). (For GP IIb/IIIa inhibitor administration in patients not pretreated with clopidogrel, Level of Evidence: A; for GP IIb/IIIa inhibitor administration in patients pretreated with clopidogrel, Level of Evidence: C)

##### CLASS IIb

1. In patients undergoing primary PCI with abciximab, it may be reasonable to administer intracoronary abciximab (297,299–312). (Level of Evidence: B)

##### CLASS III: NO BENEFIT

1. Routine precatheterization laboratory (e.g., ambulance or emergency room) administration of GP IIb/IIIa inhibitors as part of an upstream strategy for patients with STEMI undergoing PCI is not beneficial (313–320). (Level of Evidence: B)

##### UA/NSTEMI

##### CLASS I

1. In UA/NSTEMI patients with high-risk features (e.g., elevated troponin level) not treated with bivalirudin and not adequately pre-

**Table 7. Recommendations for Antiplatelet and Antithrombin Pharmacotherapy at the Time of PCI**

	COR	LOE	References	Relevant Caveats/Comments
Oral antiplatelet agents				
Aspirin	I	B	(150–153,275–278)	N/A
P2Y <sub>12</sub> Inhibitors	I	A	(279–283)	• A loading dose of a P2Y <sub>12</sub> inhibitor should be given to patients undergoing PCI with stenting.
• Clopidogrel	I	B	(279–281)	• 600-mg loading dose now recommended.
• Prasugrel	I	B	(282)	• Contraindicated in patients with prior TIA/CVA: <b>Class III: Harm; LOE: B.</b> • Generally not recommended in patients >75 years of age (see Section 5.7.2 in full text). • Consideration of using a lower maintenance dose in persons weighing <60 kg suggested by FDA (Section 5.7.2 in full text).
• Ticagrelor	I	B	(283)	• Issues of patient compliance may be especially important.
GP IIb/IIIa inhibitors (abciximab, double-bolus eptifibatide, high-bolus dose tirofiban)				
• No clopidogrel pretreatment	STEMI: IIa	A	(292–298)	• UA/NSTEMI recommendation applies to those with high-risk features. • GPI use in STEMI may be most appropriate in those with large anterior MI and/or large thrombus burden. • IC abciximab administration in STEMI: <b>Class IIb; LOE: B.</b> • Precatheterization laboratory GPI administration in STEMI: <b>Class III: No Benefit; LOE: B.</b> • Recommendations apply to those not at high risk for bleeding complications.
	UA/NSTEMI: I	A	(321–326)	
	SIHD: IIa	B	(327–329)	
• Clopidogrel pretreatment	STEMI: IIa	C	(292–298)	
	UA/NSTEMI: IIa	B	(324,327)	
	SIHD: IIb	B	(327,330–332)	
Antithrombin agents				
UFH	I	C	N/A	• Dosing based on whether or not GPI was administered
Bivalirudin	I	B	(333–342)	• Lower bleeding rates associated with bivalirudin are mitigated when used concomitantly with a GPI.
Enoxaparin	IIb	B	(343–347)	• Recommendations apply to administration of IV enoxaparin at the time of PCI for those who have not received prior antithrombin therapy or who have received “upstream” SC enoxaparin therapy for UA/NSTEMI. • An additional dose of 0.3 mg/kg IV enoxaparin should be administered at the time of PCI to patients who have received <2 therapeutic SC doses (e.g., 1 mg/kg) or received the last SC enoxaparin dose 8 to 12 h before PCI: <b>Class I; LOE: B.</b> • Patients treated with SC enoxaparin within 12 h of PCI should not receive additional treatment with UFH during PCI (“stacking”): <b>Class III: Harm; LOE: B.</b>
Anti-Xa inhibitors				
Fondaparinux	III: Harm	C	(348,349)	• PCI should not be performed with fondaparinux as the sole antithrombin agent in patients treated with upstream fondaparinux. An additional anticoagulant with anti-IIa activity should be administered.

ACT indicates activated clotting time; COR, class of recommendation; CVA, cerebrovascular accident; FDA, U.S. Food and Drug Administration; GP, glycoprotein; GPI, glycoprotein IIb/IIIa inhibitor; IC, intracoronary; IV, intravenous; LOE, level of evidence; MI, myocardial infarction; N/A, not applicable; PCI, percutaneous coronary intervention; SC, subcutaneous; SIHD, stable ischemic heart disease; STEMI, ST-elevation myocardial infarction; TIA, transient ischemic attack; UA/NSTEMI, unstable angina/non-ST-elevation myocardial infarction; and UFH, unfractionated heparin.

treated with clopidogrel, it is useful at the time of PCI to administer a GP IIb/IIIa inhibitor (abciximab, double-bolus eptifibatide, or high-bolus dose tirofiban) in patients treated with UFH (321–326). (Level of Evidence: A)

#### CLASS IIa

1. In UA/NSTEMI patients with high-risk features (e.g., elevated troponin level) treated with UFH and adequately pretreated with clopidogrel, it is reasonable at the time of PCI to administer a GP IIb/IIIa inhibitor (abciximab, double-bolus eptifibatide, or high-bolus dose tirofiban) (324,327). (Level of Evidence: B)

#### SIHD

#### CLASS IIa

1. In patients undergoing elective PCI treated with UFH and not pretreated with clopidogrel, it is reasonable to administer a GP IIb/IIIa inhibitor (abciximab, double-bolus eptifibatide, or high-bolus dose tirofiban) (327–329). (Level of Evidence: B)

#### CLASS IIb

1. In patients undergoing elective PCI with stent implantation treated with UFH and adequately pretreated with clopidogrel, it might be reasonable to administer a GP IIb/IIIa inhibitor (abciximab, double-bolus eptifibatide, or high-bolus dose tirofiban) (327,330–332). (Level of Evidence: B)

### 4.6.3. Anticoagulant Therapy

#### 4.6.3.1. USE OF PARENTERAL ANTICOAGULANTS DURING PCI

#### CLASS I

1. An anticoagulant should be administered to patients undergoing PCI. (Level of Evidence: C)

#### 4.6.3.2. UNFRACTIONATED HEPARIN

#### CLASS I

1. Administration of IV UFH is useful in patients undergoing PCI. (Level of Evidence: C)

#### 4.6.3.3. ENOXAPARIN

##### **CLASS I**

1. An additional dose of 0.3 mg/kg IV enoxaparin should be administered at the time of PCI to patients who have received fewer than 2 therapeutic subcutaneous doses (e.g., 1 mg/kg) or received the last subcutaneous enoxaparin dose 8 to 12 hours before PCI (346,350–353). (Level of Evidence: B)

##### **CLASS IIb**

1. Performance of PCI with enoxaparin may be reasonable in patients either treated with “upstream” subcutaneous enoxaparin for UA/NSTEMI or who have not received prior antithrombin therapy and are administered IV enoxaparin at the time of PCI (343–347). (Level of Evidence: B)

##### **CLASS III: HARM**

1. UFH should not be given to patients already receiving therapeutic subcutaneous enoxaparin (346,354). (Level of Evidence: B)

#### 4.6.3.4. BIVALIRUDIN AND ARGATROBAN

##### **CLASS I**

1. For patients undergoing PCI, bivalirudin is useful as an anticoagulant with or without prior treatment with UFH (333–342). (Level of Evidence: B)
2. For patients with heparin-induced thrombocytopenia, it is recommended that bivalirudin or argatroban be used to replace UFH (355,356). (Level of Evidence: B)

#### 4.6.3.5. FONDAPARINUX

##### **CLASS III: HARM**

1. Fondaparinux should not be used as the sole anticoagulant to support PCI. An additional anticoagulant with anti-IIa activity should be administered because of the risk of catheter thrombosis (348,349). (Level of Evidence: C)

#### 4.6.4. No-Reflow Pharmacological Therapies

##### **CLASS IIa**

1. Administration of an intracoronary vasodilator (adenosine, calcium channel blocker, or nitroprusside) is reasonable to treat PCI-related no-reflow that occurs during primary or elective PCI (357–372). (Level of Evidence: B)

#### 4.7. PCI in Specific Anatomic Situations

##### 4.7.1. Chronic Total Occlusions

##### **CLASS IIa**

1. PCI of a chronic total occlusion in patients with appropriate clinical indications and suitable anatomy is reasonable when performed by operators with appropriate expertise (373–377). (Level of Evidence: B)

##### 4.7.2. Saphenous Vein Grafts

##### **CLASS I**

1. Embolic protection devices should be used during saphenous vein graft PCI when technically feasible (271–274). (Level of Evidence: B)

##### **CLASS III: NO BENEFIT**

1. Platelet GP IIb/IIIa inhibitors are not beneficial as adjunctive therapy during saphenous vein graft PCI (232,286,378,379). (Level of Evidence: B)

##### **CLASS III: HARM**

1. PCI is not recommended for chronic saphenous vein graft occlusions (380–382). (Level of Evidence: C)

##### 4.7.3. Bifurcation Lesions

##### **CLASS I**

1. Provisional side-branch stenting should be the initial approach in patients with bifurcation lesions when the side branch is not large and has only mild or moderate focal disease at the ostium (383–386). (Level of Evidence: A)

##### **CLASS IIa**

1. It is reasonable to use elective double stenting in patients with complex bifurcation morphology involving a large side branch where the risk of side-branch occlusion is high and the likelihood of successful side-branch reaccess is low (387–390). (Level of Evidence: B)

##### 4.7.4. Aorto-Ostial Stenoses

##### **CLASS IIa**

1. IVUS is reasonable for the assessment of angiographically indeterminate left main CAD (391,392). (Level of Evidence: B)
2. Use of DES is reasonable when PCI is indicated in patients with an aorto-ostial stenosis (393,394). (Level of Evidence: B)

##### 4.7.5. Calcified Lesions

##### **CLASS IIa**

1. Rotational atherectomy is reasonable for fibrotic or heavily calcified lesions that might not be crossed by a balloon catheter or adequately dilated before stent implantation (258,259,395). (Level of Evidence: C)

#### 4.8. PCI in Specific Patient Populations

##### 4.8.1. Chronic Kidney Disease

##### **CLASS I**

In patients undergoing PCI, the glomerular filtration rate should be estimated and the dosage of renally cleared medications should be adjusted (147–149). (Level of Evidence: B)

#### 4.9. Periprocedural Myocardial Infarction Assessment

##### **CLASS I**

1. In patients who have signs or symptoms suggestive of myocardial infarction during or after PCI or in asymptomatic patients with significant persistent angiographic complications (e.g., large side-branch occlusion, flow-limiting dissection, no-reflow phenomenon, or coronary thrombosis), creatinine kinase-MB and troponin I or T should be measured. (Level of Evidence: C)

##### **CLASS IIb**

1. Routine measurement of cardiac biomarkers (creatinine kinase-MB and/or troponin I or T) in all patients after PCI may be reasonable. (Level of Evidence: C)

## 4.10. Vascular Closure Devices

### CLASS I

1. Patients considered for vascular closure devices should undergo a femoral angiogram to ensure their anatomic suitability for deployment. (Level of Evidence: C)

### CLASS IIa

1. The use of vascular closure devices is reasonable for the purposes of achieving faster hemostasis and earlier ambulation compared with the use of manual compression (396–399). (Level of Evidence: B)

### CLASS III: NO BENEFIT

1. The routine use of vascular closure devices is not recommended for the purpose of decreasing vascular complications, including bleeding (396–401). (Level of Evidence: B)

## 5. Postprocedural Considerations: Recommendations

Postprocedural considerations in patients undergoing PCI are discussed below and summarized in Table 8. Some recommendations and text regarding DAPT in Section 5.7.2 of the full-text guideline (4) are intentionally repeated in this section for reader ease of use.

### 5.1. Postprocedural Antiplatelet Therapy

#### CLASS I

1. After PCI, use of aspirin should be continued indefinitely (275–278). (Level of Evidence: A)
2. The duration of P2Y<sub>12</sub> inhibitor therapy after stent implantation should generally be as follows:
  - a. In patients receiving a stent (BMS or DES) during PCI for ACS, P2Y<sub>12</sub> inhibitor therapy should be given for at least 12 months. Options include clopidogrel 75 mg daily (285), prasugrel 10 mg daily (282), and ticagrelor 90 mg twice daily (283). (Level of Evidence: B)
  - b. In patients receiving DES for a non-ACS indication, clopidogrel 75 mg daily should be given for at least 12 months if the patient is not at high risk of bleeding (107,232,286). (Level of Evidence: B)
  - c. In patients receiving BMS for a non-ACS indication, clopidogrel should be given for a minimum of 1 month and ideally up to 12 months (unless the patient is at increased risk of bleeding; then it should be given for a minimum of 2 weeks) (287). (Level of Evidence: B)
3. Patients should be counseled on the importance of compliance with DAPT and that therapy should not be discontinued before discussion with their cardiologist (107). (Level of Evidence: C)

#### CLASS IIa

1. After PCI, it is reasonable to use aspirin 81 mg per day in preference to higher maintenance doses (151,288–291). (Level of Evidence: B)
2. If the risk of morbidity from bleeding outweighs the anticipated benefit afforded by a recommended duration of P2Y<sub>12</sub> inhibitor therapy after stent implantation, earlier discontinuation (e.g., <12 months) of P2Y<sub>12</sub> inhibitor therapy is reasonable. (Level of Evidence: C)

#### CLASS IIb

1. Continuation of clopidogrel, prasugrel or ticagrelor beyond 12 months may be considered in patients undergoing placement of DES (282,283). (Level of Evidence: C)

### 5.1.1. Proton Pump Inhibitors and Antiplatelet Therapy

#### CLASS I

1. Proton pump inhibitors should be used in patients with a history of prior gastrointestinal bleeding who require DAPT (402). (Level of Evidence: C)

#### CLASS IIa

1. Use of proton pump inhibitors is reasonable in patients with an increased risk of gastrointestinal bleeding (e.g., advanced age, concomitant use of warfarin, steroids, nonsteroidal anti-inflammatory drugs, *Helicobacter pylori* infection) who require DAPT (402). (Level of Evidence: C)

#### CLASS III: NO BENEFIT

1. Routine use of a proton pump inhibitor is not recommended for patients at low risk of gastrointestinal bleeding, who have much less potential to benefit from prophylactic therapy (402). (Level of Evidence: C)

### 5.1.2. Clopidogrel Genetic Testing

#### CLASS IIb

1. Genetic testing might be considered to identify whether a patient at high risk for poor clinical outcomes is predisposed to inadequate platelet inhibition with clopidogrel (434). (Level of Evidence: C)
2. When a patient predisposed to inadequate platelet inhibition with clopidogrel is identified by genetic testing, treatment with an alternate P2Y<sub>12</sub> inhibitor (e.g., prasugrel or ticagrelor) might be considered (434). (Level of Evidence: C)

#### CLASS III: NO BENEFIT

1. The routine clinical use of genetic testing to screen patients treated with clopidogrel who are undergoing PCI is not recommended (434). (Level of Evidence: C)

### 5.1.3. Platelet Function Testing

#### CLASS IIb

1. Platelet function testing may be considered in patients at high risk for poor clinical outcomes (434). (Level of Evidence: C)
2. In patients treated with clopidogrel with high platelet reactivity, alternative agents, such as prasugrel or ticagrelor, might be considered (434). (Level of Evidence: C)

#### CLASS III: NO BENEFIT

1. The routine clinical use of platelet function testing to screen patients treated with clopidogrel who are undergoing PCI is not recommended (434). (Level of Evidence: C)

## 5.2. Restenosis

#### CLASS I

1. Patients who develop clinical restenosis after balloon angioplasty should be treated with BMS or DES if anatomic factors are appropriate and if the patient is able to comply with and tolerate DAPT (435). (Level of Evidence: B)
2. Patients who develop clinical restenosis after BMS should be treated with DES if anatomic factors are appropriate and the patient



**Table 8. Postprocedural Recommendations for Patients Undergoing PCI**

Recommendations		COR	LOE	References
<b>Aspirin</b>				
After PCI, use of aspirin should be continued indefinitely.		I	A	(275–278)
After PCI, it is reasonable to use aspirin 81 mg/d in preference to higher maintenance doses.		IIa	B	(151,288–291)
<b>P2Y<sub>12</sub> inhibitors</b>				
In patients receiving a stent (BMS or DES) during PCI for ACS, P2Y <sub>12</sub> inhibitor therapy should be given for at least 12 mo. Options include clopidogrel 75 mg/d, prasugrel 10 mg/d, and ticagrelor 90 mg twice daily.		I	B	(282,283,285)
In patients receiving DES for a non-ACS indication, clopidogrel 75 mg/d should be given for at least 12 mo if patients are not at high risk of bleeding.		I	B	(107,232,286)
In patients receiving BMS for a non-ACS indication, clopidogrel should be given for a minimum of 1 mo and ideally up to 12 mo (unless the patient is at increased risk of bleeding; then it should be given for a minimum of 2 wk).		I	B	(287)
Patients should be counseled on the importance of compliance with DAPT and that therapy should not be discontinued before discussion with their cardiologist.		I	C	(107)
PPIs should be used in patients with a history of prior GI bleeding who require DAPT.		I	C	(402)
If the risk of morbidity from bleeding outweighs the anticipated benefit afforded by a recommended duration of P2Y <sub>12</sub> inhibitor therapy after stent implantation, earlier discontinuation (e.g., <12 mo) of P2Y <sub>12</sub> inhibitor therapy is reasonable.		IIa	C	N/A
Use of PPIs is reasonable in patients with an increased risk of GI bleeding (e.g., advanced age, concomitant use of warfarin, steroids, NSAIDs, <i>Helicobacter pylori</i> infection) who require DAPT.		IIa	C	(402)
Continuation of clopidogrel, prasugrel, or ticagrelor beyond 12 mo may be considered in patients undergoing placement of DES.		IIb	C	(282,283)
Routine use of a PPI is not recommended for patients at low risk of GI bleeding, who have much less potential to benefit from prophylactic therapy.		III: No Benefit	C	(402)
<b>Exercise testing</b>				
For patients entering a formal cardiac rehabilitation program after PCI, treadmill exercise testing is reasonable.		IIa	C	N/A
Routine periodic stress testing of asymptomatic patients after PCI without specific clinical indications should not be performed.		III: No Benefit	C	(403)
<b>Cardiac rehabilitation</b>				
Medically supervised exercise programs (cardiac rehabilitation) should be recommended to patients after PCI, particularly for patients at moderate to high risk for whom supervised exercise training is warranted.		I	A	(404–412)
<b>Secondary prevention</b> (recommendations included from the 2011 AHA/ACCF Secondary Prevention and Risk Reduction Therapy Guideline) (413)				
Lipid management with lifestyle modification and lipid-lowering pharmacotherapy	Lifestyle modification	I	B	(414,415)
	Statin therapy	I	A	(414,416–419,419a)
	Statin therapy which lowers LDL cholesterol to <100 mg/dL and achieves at least a 30% lowering of LDL cholesterol	I	C	(414–419,419a)
	Statin therapy which lowers LDL cholesterol to <70 mg/dL in very high-risk* patients	IIa	C	(416–418,419a,420–422)
Blood pressure control (with a blood pressure goal of <140/90 mm Hg)	Lifestyle modification	I	B	(423–427)
	Pharmacotherapy	I	A	(423,428,429)
Diabetes management (e.g., lifestyle modification and pharmacotherapy) coordinated with the patient's primary care physician and/or endocrinologist		I	C	N/A
Complete smoking cessation		I	A	(430–433)

\*Presence of established cardiovascular disease plus 1) multiple major risk factors (especially diabetes), 2) severe and poorly controlled risk factors (especially continued cigarette smoking), 3) multiple risk factors of the metabolic syndrome (especially high triglycerides  $\geq 200$  mg/dL plus non-HDL-cholesterol  $\geq 130$  mg/dL with low HDL-cholesterol [ $<40$  mg/dL]), and 4) acute coronary syndromes. ACS indicates acute coronary syndromes; BMS, bare-metal stent(s); COR, class of recommendation; DAPT, dual antiplatelet therapy; DES, drug-eluting stent(s); GI, gastrointestinal; HDL, high-density lipoprotein; LDL, low-density lipoprotein; LOE, level of evidence; N/A, not applicable; NSAID, nonsteroidal anti-inflammatory drug; PCI, percutaneous coronary intervention; and PPI, proton pump inhibitor.

is able to comply with and tolerate DAPT (436–438). (Level of Evidence: A)

#### CLASS IIa

- IVUS is reasonable to determine the mechanism of stent restenosis (254). (Level of Evidence: C)

#### CLASS IIb

- Patients who develop clinical restenosis after DES may be considered for repeat PCI with balloon angioplasty, BMS, or DES containing the same drug or an alternative antiproliferative drug if anatomic factors are appropriate and the patient is able to comply with and tolerate DAPT (254). (Level of Evidence: C)

### 5.2.1. Exercise Testing

#### CLASS IIa

1. In patients entering a formal cardiac rehabilitation program after PCI, treadmill exercise testing is reasonable. (Level of Evidence: C)

#### CLASS III: NO BENEFIT

1. Routine periodic stress testing of asymptomatic patients after PCI without specific clinical indications should not be performed (403). (Level of Evidence: C)

### 5.2.2. Cardiac Rehabilitation

#### CLASS I

1. Medically supervised exercise programs (cardiac rehabilitation) should be recommended to patients after PCI, particularly for moderate- to high-risk patients for whom supervised exercise training is warranted (404–412). (Level of Evidence: A)

## 6. Quality and Performance Considerations: Recommendations

### 6.1. Quality and Performance

#### CLASS I

1. Every PCI program should operate a quality-improvement program that routinely 1) reviews quality and outcomes of the entire program; 2) reviews results of individual operators; 3) includes risk adjustment; 4) provides peer review of difficult or complicated cases; and 5) performs random case reviews. (Level of Evidence: C)
2. Every PCI program should participate in a regional or national PCI registry for the purpose of benchmarking its outcomes against current national norms. (Level of Evidence: C)

### 6.2. Certification and Maintenance of Certification

#### CLASS IIa

1. It is reasonable for all physicians who perform PCI to participate in the American Board of Internal Medicine interventional cardiology board certification and maintenance of certification program. (Level of Evidence: C)

### 6.3. Operator and Institutional Competency and Volume

#### CLASS I

1. Elective/urgent PCI should be performed by operators with an acceptable annual volume ( $\geq 75$  procedures) at high-volume centers ( $>400$  procedures) with on-site cardiac surgery (439,440). (Level of Evidence: C)
2. Elective/urgent PCI should be performed by operators and institutions whose current risk-adjusted outcomes statistics are comparable to those reported in contemporary national data registries. (Level of Evidence: C)
3. Primary PCI for STEMI should be performed by experienced operators who perform more than 75 elective PCI procedures per year and, ideally, at least 11 PCI procedures for STEMI per year. Ideally, these procedures should be performed in institutions that perform more than 400 elective PCIs per year and more than 36 primary PCI procedures for STEMI per year (439,441–444). (Level of Evidence: C)

#### CLASS IIa

1. It is reasonable that operators with acceptable volume ( $\geq 75$  PCI procedures per year) perform elective/urgent PCI at low-volume centers (200 to 400 PCI procedures per year) with on-site cardiac surgery (439). (Level of Evidence: C)
2. It is reasonable that low-volume operators ( $<75$  PCI procedures per year) perform elective/urgent PCI at high-volume centers ( $>400$  PCI procedures per year) with on-site cardiac surgery. Ideally, operators with an annual procedure volume of fewer than 75 procedures per year should only work at institutions with an activity level of more than 600 procedures per year. Operators who perform fewer than 75 procedures per year should develop a defined mentoring relationship with a highly experienced operator who has an annual procedural volume of at least 150 procedures. (Level of Evidence: C)

#### CLASS IIb

1. The benefit of primary PCI for STEMI patients eligible for fibrinolysis when performed by an operator who performs fewer than 75 procedures per year ( $<11$  PCIs for STEMI per year) is not well established. (Level of Evidence: C)

#### CLASS III: NO BENEFIT

1. It is not recommended that elective/urgent PCI be performed by low-volume operators ( $<75$  procedures per year) at low-volume centers (200 to 400 procedures per year) with or without on-site cardiac surgery. An institution with a volume of fewer than 200 procedures per year, unless in a region that is underserved because of geography, should carefully consider whether it should continue to offer this service (439). (Level of Evidence: C)

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## REFERENCES

1. ACCF/AHA Task Force on Practice Guidelines. Methodologies and Policies from the ACCF/AHA Task Force on Practice Guidelines. Available at: [http://assets.cardiosource.com/Methodology\\_Manual\\_for\\_ACC\\_AHA\\_Writing\\_Committees.pdf](http://assets.cardiosource.com/Methodology_Manual_for_ACC_AHA_Writing_Committees.pdf) and <http://circ.ahajournals.org/site/manual/index.xhtml>. Accessed July 1, 2011.
2. Institute of Medicine. Finding What Works in Health Care: Standards for Systematic Reviews. Washington, DC: The National Academies Press; 2011.
3. Institute of Medicine. Clinical Practice Guidelines We Can Trust. Washington, DC: The National Academies Press; 2011.
4. Levine GN, Bates ER, Blankenship JC, et al. 2011 ACCF/AHA/SCAI guideline for percutaneous coronary intervention. *J Am Coll Cardiol*, published online before print November 7, 2011, doi: 10.1016/j.jacc.2011.08.007. Accessed November 7, 2011.
5. Feit F, Brooks MM, Sopko G, et al., BARI Investigators. Long-term clinical outcome in the Bypass Angioplasty Revascularization Investigation Registry: comparison with the randomized trial. *Circulation*. 2000;101:2795–802.
6. King SBI, Barnhart HX, Kosinski AS, et al., Emory Angioplasty versus Surgery Trial Investigators. Angioplasty or surgery for multivessel coronary artery disease: comparison of eligible registry and randomized patients in the EAST trial and influence of treatment selection on outcomes. *Am J Cardiol*. 1997;79:1453–9.
7. Serruys PW, Morice MC, Kappetein AP, et al. Percutaneous coronary intervention versus coronary-artery bypass grafting for severe coronary artery disease. *N Engl J Med*. 2009;360:961–72.
8. Chakravarty T, Buch MH, Naik H, et al. Predictive accuracy of SYNTAX score for predicting long-term outcomes of unprotected left main coronary artery revascularization. *Am J Cardiol*. 2011;107:360–6.
9. Grover FL, Shroyer AL, Hammermeister K, et al. A decade's experience with quality improvement in cardiac surgery using the Veterans Affairs and Society of Thoracic Surgeons national databases. *Ann Surg*. 2001;234:464–72.
10. Kim YH, Park DW, Kim WJ, et al. Validation of SYNTAX (Synergy between PCI with TAXUS and Cardiac Surgery) score for prediction of outcomes after unprotected left main coronary revascularization. *J Am Coll Cardiol Interv*. 2010;3:612–23.
11. Morice MC, Serruys PW, Kappetein AP, et al. Outcomes in patients with de novo left main disease treated with either percutaneous coronary intervention using paclitaxel-eluting stents or coronary artery bypass graft treatment in the Synergy Between Percutaneous Coronary Intervention with TAXUS and Cardiac Surgery (SYNTAX) trial. *Circulation*. 2010;121:2645–53.
12. Shahian DM, O'Brien SM, Filardo G, et al. The Society of Thoracic Surgeons 2008 cardiac surgery risk models: part 1—coronary artery bypass grafting surgery. *Ann Thorac Surg*. 2009;88 Suppl 1:S2–22.
13. Shahian DM, O'Brien SM, Normand SL, et al. Association of hospital coronary artery bypass volume with processes of care, mortality, morbidity, and the Society of Thoracic Surgeons composite quality score. *J Thorac Cardiovasc Surg*. 2010;139:273–82.
14. Welke KF, Peterson ED, Vaughan-Sarrazin MS, et al. Comparison of cardiac surgery volumes and mortality rates between the Society of Thoracic Surgeons and Medicare databases from 1993 through 2001. *Ann Thorac Surg*. 2007;84:1538–46.
15. Caracciolo EA, Davis KB, Sopko G, et al. Comparison of surgical and medical group survival in patients with left main coronary artery disease. Long-term CASS experience. *Circulation*. 1995;91:2325–34.
16. Chaitman BR, Fisher LD, Bourassa MG, et al. Effect of coronary bypass surgery on survival patterns in subsets of patients with left main coronary artery disease. Report of the Collaborative Study in Coronary Artery Surgery (CASS). *Am J Cardiol*. 1981;48:765–77.
17. Dzavik V, Ghali WA, Norris C, et al. Long-term survival in 11,661 patients with multivessel coronary artery disease in the era of stenting: a report from the Alberta Provincial Project for Outcome Assessment in Coronary Heart Disease (APPROACH) Investigators. *Am Heart J*. 2001;142:119–26.
18. Takaro T, Hultgren HN, Lipton MJ, et al. The VA cooperative randomized study of surgery for coronary arterial occlusive disease II. Subgroup with significant left main lesions. *Circulation*. 1976;54:III107–17.
19. Takaro T, Peduzzi P, Detre KM, et al. Survival in subgroups of patients with left main coronary artery disease. Veterans Administration Cooperative Study of Surgery for Coronary Arterial Occlusive Disease. *Circulation*. 1982;66:14–22.
20. Taylor HA, Deumite NJ, Chaitman BR, et al. Asymptomatic left main coronary artery disease in the Coronary Artery Surgery Study (CASS) registry. *Circulation*. 1989;79:1171–9.
21. Yusuf S, Zucker D, Peduzzi P, et al. Effect of coronary artery bypass graft surgery on survival: overview of 10-year results from randomised trials by the Coronary Artery Bypass Graft Surgery Trialists Collaboration. *Lancet*. 1994;344:563–70.
22. Capodanno D, Caggigi A, Miano M, et al. Global risk classification and Clinical SYNTAX (Synergy between Percutaneous Coronary Intervention with TAXUS and Cardiac Surgery) score in patients undergoing percutaneous or surgical left main revascularization. *J Am Coll Cardiol Interv*. 2011;4:287–97.
23. Hannan EL, Wu C, Walford G, et al. Drug-eluting stents vs coronary-artery bypass grafting in multivessel coronary disease. *N Engl J Med*. 2008;358:331–41.
24. Ellis SG, Tamai H, Nobuyoshi M, et al. Contemporary percutaneous treatment of unprotected left main coronary stenoses: initial results from a multicenter registry analysis 1994–1996. *Circulation*. 1997;96:3867–72.
25. Biondi-Zoccai GG, Lotrionte M, Moretti C, et al. A collaborative systematic review and meta-analysis on 1278 patients undergoing percutaneous drug-eluting stenting for unprotected left main coronary artery disease. *Am Heart J*. 2008;155:274–83.
26. Boudriot E, Thiele H, Walther T, et al. Randomized comparison of percutaneous coronary intervention with sirolimus-eluting stents versus coronary artery bypass grafting in unprotected left main stem stenosis. *J Am Coll Cardiol*. 2011;57:538–45.
27. Brener SJ, Galla JM, Bryant R. I, et al. Comparison of percutaneous versus surgical revascularization of severe unprotected left main coronary stenosis in matched patients. *Am J Cardiol*. 2008;101:169–72.
28. Buszman PE, Kiesz SR, Bochenek A, et al. Acute and late outcomes of unprotected left main stenting in comparison with surgical revascularization. *J Am Coll Cardiol*. 2008;51:538–45.
29. Chieffo A, Magni V, Latib A, et al. 5-year outcomes following percutaneous coronary intervention with drug-eluting stent implantation versus coronary artery bypass graft for unprotected left main coronary artery lesions: the Milan experience. *J Am Coll Cardiol Interv*. 2010;3:595–601.
30. Chieffo A, Morici N, Maisano F, et al. Percutaneous treatment with drug-eluting stent implantation versus bypass surgery for unprotected left main stenosis: a single-center experience. *Circulation*. 2006;113:2542–7.
31. Lee MS, Kapoor N, Jamal F, et al. Comparison of coronary artery bypass surgery with percutaneous coronary intervention with drug-eluting stents for unprotected left main coronary artery disease. *J Am Coll Cardiol*. 2006;47:864–70.
32. Makikallio TH, Niemela M, Kervinen K, et al. Coronary angioplasty in drug eluting stent era for the treatment of unprotected left main stenosis compared to coronary artery bypass grafting. *Ann Med*. 2008;40:437–43.
33. Naik H, White AJ, Chakravarty T, et al. A meta-analysis of 3,773 patients treated with percutaneous coronary intervention or surgery for unprotected left main coronary artery stenosis. *J Am Coll Cardiol Interv*. 2009;2:739–47.
34. Palmerini T, Marzocchi A, Marzocchi C, et al. Comparison between coronary angioplasty and coronary artery bypass surgery for the treatment of unprotected left main coronary artery stenosis (the Bologna Registry). *Am J Cardiol*. 2006;98:54–9.
35. Park DW, Seung KB, Kim YH, et al. Long-term safety and efficacy of stenting versus coronary artery bypass grafting for unprotected left main coronary artery disease: 5-year results from the MAIN-COMPARE (Revascularization for Unprotected Left Main Coronary Artery Stenosis: Comparison of Percutaneous Coronary Angioplasty Versus Surgical Revascularization) registry. *J Am Coll Cardiol*. 2010;56:117–24.
36. Rodes-Cabau J, Deblois J, Bertrand OF, et al. Nonrandomized comparison of coronary artery bypass surgery and percutaneous coronary intervention for the treatment of unprotected left main coronary artery disease in octogenarians. *Circulation*. 2008;118:2374–81.



37. Sanmartin M, Baz JA, Claro R, et al. Comparison of drug-eluting stents versus surgery for unprotected left main coronary artery disease. *Am J Cardiol.* 2007;100:970–3.
38. Kappetein AP, Mohr FW, Feldman TE, et al. Comparison of coronary bypass surgery with drug-eluting stenting for the treatment of left main and/or three-vessel disease: 3-year follow-up of the SYNTAX trial. *Eur Heart J.* 2011;17:2125–34.
39. Seung KB, Park DW, Kim YH, et al. Stents versus coronary-artery bypass grafting for left main coronary artery disease. *N Engl J Med.* 2008;358:1781–92.
40. White AJ, Kedia G, Mirocha JM, et al. Comparison of coronary artery bypass surgery and percutaneous drug-eluting stent implantation for treatment of left main coronary artery stenosis. *J Am Coll Cardiol Interv.* 2008;1:236–45.
41. Montalescot G, Brieger D, Eagle KA, et al. Unprotected left main revascularization in patients with acute coronary syndromes. *Eur Heart J.* 2009;30:2308–17.
42. Lee MS, Tseng CH, Barker CM, et al. Outcome after surgery and percutaneous intervention for cardiogenic shock and left main disease. *Ann Thorac Surg.* 2008;86:29–34.
43. Lee MS, Bokhoo P, Park SJ, et al. Unprotected left main coronary disease and ST-segment elevation myocardial infarction: a contemporary review and argument for percutaneous coronary intervention. *J Am Coll Cardiol Interv.* 2010;3:791–5.
44. Park SJ, Kim YH, Park DW, et al. Randomized trial of stents versus bypass surgery for left main coronary artery disease. *N Engl J Med.* 2011;364:1718–27.
45. Jones RH, Kesler K, Phillips HR, III, et al. Long-term survival benefits of coronary artery bypass grafting and percutaneous transluminal angioplasty in patients with coronary artery disease. *J Thorac Cardiovasc Surg.* 1996;111:1013–25.
46. Myers WO, Schaff HV, Gersh BJ, et al. Improved survival of surgically treated patients with triple vessel coronary artery disease and severe angina pectoris. A report from the Coronary Artery Surgery Study (CASS) registry. *J Thorac Cardiovasc Surg.* 1989;97:487–95.
47. Varnauskas E. Twelve-year follow-up of survival in the randomized European Coronary Surgery Study. *N Engl J Med.* 1988;319:332–7.
48. Smith PK, Califf RM, Tuttle RH, et al. Selection of surgical or percutaneous coronary intervention provides differential longevity benefit. *Ann Thorac Surg.* 2006;82:1420–8.
49. Borger van der Burg AE, Bax JJ, Boersma E, et al. Impact of percutaneous coronary intervention or coronary artery bypass grafting on outcome after nonfatal cardiac arrest outside the hospital. *Am J Cardiol.* 2003;91:785–9.
50. Every NR, Fahrenbruch CE, Hallstrom AP, et al. Influence of coronary bypass surgery on subsequent outcome of patients resuscitated from out of hospital cardiac arrest. *J Am Coll Cardiol.* 1992;19:1435–9.
51. Kaiser GA, Ghahramani A, Bolooki H, et al. Role of coronary artery surgery in patients surviving unexpected cardiac arrest. *Surgery.* 1975;78:749–54.
52. Di Carli MF, Maddahi J, Rokhsar S, et al. Long-term survival of patients with coronary artery disease and left ventricular dysfunction: implications for the role of myocardial viability assessment in management decisions. *J Thorac Cardiovasc Surg.* 1998;116:997–1004.
53. Hachamovitch R, Hayes SW, Friedman JD, et al. Comparison of the short-term survival benefit associated with revascularization compared with medical therapy in patients with no prior coronary artery disease undergoing stress myocardial perfusion single photon emission computed tomography. *Circulation.* 2003;107:2900–7.
54. Sorajja P, Chareonthaitawee P, Rajagopalan N, et al. Improved survival in asymptomatic diabetic patients with high-risk SPECT imaging treated with coronary artery bypass grafting. *Circulation.* 2005;112:1311–6.
55. Davies RF, Goldberg AD, Forman S, et al. Asymptomatic Cardiac Ischemia Pilot (ACIP) study two-year follow-up: outcomes of patients randomized to initial strategies of medical therapy versus revascularization. *Circulation.* 1997;95:2037–43.
56. Alderman EL, Fisher LD, Litwin P, et al. Results of coronary artery surgery in patients with poor left ventricular function (CASS). *Circulation.* 1983;68:785–95.
57. O'Connor CM, Velazquez EJ, Gardner LH, et al. Comparison of coronary artery bypass grafting versus medical therapy on long-term outcome in patients with ischemic cardiomyopathy (a 25-year experience from the Duke Cardiovascular Disease Databank). *Am J Cardiol.* 2002;90:101–7.
58. Phillips HR, O'Connor CM, Rogers J. Revascularization for heart failure. *Am Heart J.* 2007;153:65–73.
59. Tarakji KG, Brunken R, McCarthy PM, et al. Myocardial viability testing and the effect of early intervention in patients with advanced left ventricular systolic dysfunction. *Circulation.* 2006;113:230–7.
60. Tsuyuki RT, Shrive FM, Galbraith PD, et al. Revascularization in patients with heart failure. *CMAJ.* 2006;175:361–5.
61. Cameron A, Davis KB, Green G, et al. Coronary bypass surgery with internal-thoracic-artery grafts—effects on survival over a 15-year period. *N Engl J Med.* 1996;334:216–9.
62. Loop FD, Lytle BW, Cosgrove DM, et al. Influence of the internal-mammary-artery graft on 10-year survival and other cardiac events. *N Engl J Med.* 1986;314:1–6.
63. Brener SJ, Lytle BW, Casserly IP, et al. Propensity analysis of long-term survival after surgical or percutaneous revascularization in patients with multivessel coronary artery disease and high-risk features. *Circulation.* 2004;109:2290–5.
64. Hannan EL, Racz MJ, Walford G, et al. Long-term outcomes of coronary-artery bypass grafting versus stent implantation. *N Engl J Med.* 2005;352:2174–83.
65. Deleted in proof.
66. The BARI Investigators. Influence of diabetes on 5-year mortality and morbidity in a randomized trial comparing CABG and PTCA in patients with multivessel disease: the Bypass Angioplasty Revascularization Investigation (BARI). *Circulation.* 1997;96:1761–9.
67. The BARI Investigators. The final 10-year follow-up results from the BARI randomized trial. *J Am Coll Cardiol.* 2007;49:1600–6.
68. Banning AP, Westaby S, Morice MC, et al. Diabetic and nondiabetic patients with left main and/or 3-vessel coronary artery disease: comparison of outcomes with cardiac surgery and paclitaxel-eluting stents. *J Am Coll Cardiol.* 2010;55:1067–75.
69. Hoffman SN, TenBrook JA, Wolf MP, et al. A meta-analysis of randomized controlled trials comparing coronary artery bypass graft with percutaneous transluminal coronary angioplasty: one- to eight-year outcomes. *J Am Coll Cardiol.* 2003;41:1293–304.
70. Hueb W, Lopes NH, Gersh BJ, et al. Five-year follow-up of the Medicine, Angioplasty, or Surgery Study (MASS II): a randomized controlled clinical trial of 3 therapeutic strategies for multivessel coronary artery disease. *Circulation.* 2007;115:1082–9.
71. Malenka DJ, Leavitt BJ, Hearne MJ, et al. Comparing long-term survival of patients with multivessel coronary disease after CABG or PCI: analysis of BARI-like patients in northern New England. *Circulation.* 2005;112:1371–6.
72. Niles NW, McGrath PD, Malenka D, et al. Northern New England Cardiovascular Disease Study Group. Survival of patients with diabetes and multivessel coronary artery disease after surgical or percutaneous coronary revascularization: results of a large regional prospective study. *J Am Coll Cardiol.* 2001;37:1008–15.
73. Weintraub WS, Stein B, Kosinski A, et al. Outcome of coronary bypass surgery versus coronary angioplasty in diabetic patients with multivessel coronary artery disease. *J Am Coll Cardiol.* 1998;31:10–9.
74. Boden WE, O'Rourke RA, Teo KK, et al. Optimal medical therapy with or without PCI for stable coronary disease. *N Engl J Med.* 2007;356:1503–16.
75. Bonow RO, Maurer G, Lee KL, et al. Myocardial viability and survival in ischemic left ventricular dysfunction. *N Engl J Med.* 2011;364:1617–25.
76. Velazquez EJ, Lee KL, Deja MA, et al. Coronary artery bypass surgery in patients with left ventricular dysfunction. *N Engl J Med.* 2011;364:1607–16.
77. Brener SJ, Lytle BW, Casserly IP, et al. Predictors of revascularization method and long-term outcome of percutaneous coronary intervention or repeat coronary bypass surgery in patients with multivessel coronary disease and previous coronary bypass surgery. *Eur Heart J.* 2006;27:413–8.
78. Gurfinkel EP, Perez de la Hoz R, Brito VM, et al. Invasive vs non-invasive treatment in acute coronary syndromes and prior bypass surgery. *Int J Cardiol.* 2007;119:65–72.
79. Lytle BW, Loop FD, Taylor PC, et al. The effect of coronary reoperation on the survival of patients with stenoses in saphenous



- vein bypass grafts to coronary arteries. *J Thorac Cardiovasc Surg.* 1993;105:605–12.
80. Morrison DA, Sethi G, Sacks J, et al. Percutaneous coronary intervention versus coronary artery bypass graft surgery for patients with medically refractory myocardial ischemia and risk factors for adverse outcomes with bypass: a multicenter, randomized trial. Investigators of the Department of Veterans Affairs Cooperative Study #385, the Angina With Extremely Serious Operative Mortality Evaluation (AWESOME). *J Am Coll Cardiol.* 2001;38:143–9.
81. Pfautsch P, Frantz E, Ellmer A, et al. [Long-term outcome of therapy of recurrent myocardial ischemia after surgical revascularization]. *Z Kardiol.* 1999;88:489–97.
82. Sergeant P, Blackstone E, Meyns B, et al. First cardiologic or cardio-surgical reintervention for ischemic heart disease after primary coronary artery bypass grafting. *Eur J Cardiothorac Surg.* 1998;14:480–7.
83. Stephan WJ, O'Keefe JH Jr., Pichler JM, et al. Coronary angioplasty versus repeat coronary artery bypass grafting for patients with previous bypass surgery. *J Am Coll Cardiol.* 1996;28:1140–6.
84. Subramanian S, Sabik JFI, Houghtaling PL, et al. Decision-making for patients with patent left internal thoracic artery grafts to left anterior descending. *Ann Thorac Surg.* 2009;87:1392–8.
85. Weintraub WS, Jones EL, Morris DC, et al. Outcome of reoperative coronary bypass surgery versus coronary angioplasty after previous bypass surgery. *Circulation.* 1997;95:868–77.
86. Shaw LJ, Berman DS, Maron DJ, et al. Optimal medical therapy with or without percutaneous coronary intervention to reduce ischemic burden: results from the Clinical Outcomes Utilizing Revascularization and Aggressive Drug Evaluation (COURAGE) trial nuclear substudy. *Circulation.* 2008;117:1283–91.
87. Cashin WL, Sanmarco ME, Nessim SA, et al. Accelerated progression of atherosclerosis in coronary vessels with minimal lesions that are bypassed. *N Engl J Med.* 1984;824–8.
88. Pijls NH, De Bruyne B, Peels K, et al. Measurement of fractional flow reserve to assess the functional severity of coronary-artery stenoses. *N Engl J Med.* 1996;334:1703–8.
89. Tonino PA, De Bruyne B, Pijls NH, et al. Fractional flow reserve versus angiography for guiding percutaneous coronary intervention. *N Engl J Med.* 2009;360:213–24.
90. Sawada S, Bapat A, Vaz D, et al. Incremental value of myocardial viability for prediction of long-term prognosis in surgically revascularized patients with left ventricular dysfunction. *J Am Coll Cardiol.* 2003;42:2099–105.
91. Trial of invasive versus medical therapy in elderly patients with chronic symptomatic coronary-artery disease (TIME): a randomised trial. *Lancet.* 2001;358:951–7.
92. Benzer W, Hofer S, Oldridge NB. Health-related quality of life in patients with coronary artery disease after different treatments for angina in routine clinical practice. *Herz.* 2003;28:421–8.
93. Bonaros N, Schachner T, Ohlinger A, et al. Assessment of health-related quality of life after coronary revascularization. *Heart Surg Forum.* 2005;8:E380–5.
94. Bucher HC, Hengstler P, Schindler C, et al. Percutaneous transluminal coronary angioplasty versus medical treatment for non-acute coronary heart disease: meta-analysis of randomised controlled trials. *BMJ.* 2000;321:73–7.
95. Favarato ME, Hueb W, Boden WE, et al. Quality of life in patients with symptomatic multivessel coronary artery disease: a comparative post hoc analyses of medical, angioplasty or surgical strategies—MASS II trial. *Int J Cardiol.* 2007;116:364–70.
96. Hueb W, Lopes N, Gersh BJ, et al. Ten-year follow-up survival of the Medicine, Angioplasty, or Surgery Study (MASS II): a randomized controlled clinical trial of 3 therapeutic strategies for multivessel coronary artery disease. *Circulation.* 2010;122:949–57.
97. Pocock SJ, Henderson RA, Seed P, et al. Quality of life, employment status, and anginal symptoms after coronary angioplasty or bypass surgery. 3-year follow-up in the Randomized Intervention Treatment of Angina (RITA) Trial. *Circulation.* 1996;94:135–42.
98. Pocock SJ, Henderson RA, Clayton T, et al. Quality of life after coronary angioplasty or continued medical treatment for angina: three-year follow-up in the RITA-2 trial. Randomized Intervention Treatment of Angina. *J Am Coll Cardiol.* 2000;35:907–14.
99. Weintraub WS, Spertus JA, Kolm P, et al. Effect of PCI on quality of life in patients with stable coronary disease. *N Engl J Med.* 2008;359:677–87.
100. Wijeyesundera HC, Nallamothu BK, Krumholz HM, et al. Meta-analysis: effects of percutaneous coronary intervention versus medical therapy on angina relief. *Ann Intern Med.* 2010;152:370–9.
101. Schofield PM, Sharples LD, Caine N, et al. Transmyocardial laser revascularisation in patients with refractory angina: a randomised controlled trial. *Lancet.* 1999;353:519–24.
102. Aaberge L, Nordstrand K, Dragsund M, et al. Transmyocardial revascularization with CO<sub>2</sub> laser in patients with refractory angina pectoris. Clinical results from the Norwegian randomized trial. *J Am Coll Cardiol.* 2000;35:1170–7.
103. Burkhoff D, Schmidt S, Schulman SP, et al., ATLANTIC Investigators. Transmyocardial laser revascularisation compared with continued medical therapy for treatment of refractory angina pectoris: a prospective randomised trial. *Angina Treatments-Lasers and Normal Therapies in Comparison.* *Lancet.* 1999;354:885–90.
104. Allen KB, Dowling RD, DelRossi AJ, et al. Transmyocardial laser revascularization combined with coronary artery bypass grafting: a multicenter, blinded, prospective, randomized, controlled trial. *J Thorac Cardiovasc Surg.* 2000;119:540–9.
105. Stamou SC, Boyce SW, Cooke RH, et al. One-year outcome after combined coronary artery bypass grafting and transmyocardial laser revascularization for refractory angina pectoris. *Am J Cardiol.* 2002;89:1365–8.
106. Kappetein A, Feldman T, Mack M. Comparison of coronary artery bypass surgery with drug-eluting stenting for the treatment of left main and/or three-vessel disease: 3-year follow-up of the SYNTAX trial. *Eur Heart J.* 2011;32:2125–34.
107. Grines CL, Bonow RO, Casey DE Jr., et al. Prevention of premature discontinuation of dual antiplatelet therapy in patients with coronary artery stents: a science advisory from the American Heart Association, American College of Cardiology, Society for Cardiovascular Angiography and Interventions, American College of Surgeons, and American Dental Association, with representation from the American College of Physicians. *J Am Coll Cardiol.* 2007;49:734–9.
108. Leon MB, Baim DS, Popma JJ, et al., Stent Anticoagulation Restenosis Study Investigators. A clinical trial comparing three antithrombotic-drug regimens after coronary-artery stenting. *N Engl J Med.* 1998;339:1665–71.
109. Mauri L, Hsieh WH, Massaro JM, et al. Stent thrombosis in randomized clinical trials of drug-eluting stents. *N Engl J Med.* 2007;356:1020–9.
110. McFadden EP, Stabile E, Regar E, et al. Late thrombosis in drug-eluting coronary stents after discontinuation of antiplatelet therapy. *Lancet.* 2004;364:1519–21.
111. Bonatti J, Schachner T, Bonaros N, et al. Simultaneous hybrid coronary revascularization using totally endoscopic left internal mammary artery bypass grafting and placement of rapamycin eluting stents in the same interventional session. The COMBINATION pilot study. *Cardiology.* 2008;110:92–5.
112. Gilard M, Bezon E, Cornily JC, et al. Same-day combined percutaneous coronary intervention and coronary artery surgery. *Cardiology.* 2007;108:363–7.
113. Holzhay DM, Jacobs S, Mochalski M, et al. Minimally invasive hybrid coronary artery revascularization. *Ann Thorac Surg.* 2008;86:1856–60.
114. Kon ZN, Brown EN, Tran R, et al. Simultaneous hybrid coronary revascularization reduces postoperative morbidity compared with results from conventional off-pump coronary artery bypass. *J Thorac Cardiovasc Surg.* 2008;135:367–75.
115. Reicher B, Poston RS, Mehra MR, et al. Simultaneous “hybrid” percutaneous coronary intervention and minimally invasive surgical bypass grafting: feasibility, safety, and clinical outcomes. *Am Heart J.* 2008;155:661–7.
116. Vassiliades TA Jr., Douglas JS, Morris DC, et al. Integrated coronary revascularization with drug-eluting stents: immediate and seven-month outcome. *J Thorac Cardiovasc Surg.* 2006;131:956–62.
117. Zhao DX, Leacche M, Balaguer JM, et al. Routine intraoperative completion angiography after coronary artery bypass grafting and 1-stop hybrid revascularization: results from a fully integrated hybrid catheterization laboratory/operating room. *J Am Coll Cardiol.* 2009;53:232–41.

118. Mehran R, Aymong ED, Nikolsky E, et al. A simple risk score for prediction of contrast-induced nephropathy after percutaneous coronary intervention: development and initial validation. *J Am Coll Cardiol*. 2004;44:1393–9.
119. Moscucci M, Rogers EK, Montoyo C, et al. Association of a continuous quality improvement initiative with practice and outcome variations of contemporary percutaneous coronary interventions. *Circulation*. 2006;113:814–22.
120. Bader BD, Berger ED, Heede MB, et al. What is the best hydration regimen to prevent contrast media-induced nephrotoxicity? *Clin Nephrol*. 2004;62:1–7.
121. Mueller C, Buerkle G, Buettner HJ, et al. Prevention of contrast media-associated nephropathy: randomized comparison of 2 hydration regimens in 1620 patients undergoing coronary angioplasty. *Arch Intern Med*. 2002;162:329–36.
122. Solomon R, Werner C, Mann D, et al. Effects of saline, mannitol, and furosemide to prevent acute decreases in renal function induced by radiocontrast agents. *N Engl J Med*. 1994;331:1416–20.
123. Trivedi HS, Moore H, Nasr S, et al. A randomized prospective trial to assess the role of saline hydration on the development of contrast nephrotoxicity. *Nephron Clin Pract*. 2003;93:C29–34.
124. Marenzi G, Assanelli E, Campodonico J, et al. Contrast volume during primary percutaneous coronary intervention and subsequent contrast-induced nephropathy and mortality. *Ann Intern Med*. 2009;150:170–7.
125. McCullough PA, Wolyn R, Rocher LL, et al. Acute renal failure after coronary intervention: incidence, risk factors, and relationship to mortality. *Am J Med*. 1997;103:368–75.
126. Russo D, Minutolo R, Cianciaruso B, et al. Early effects of contrast media on renal hemodynamics and tubular function in chronic renal failure. *J Am Soc Nephrol*. 1995;6:1451–8.
127. Gonzales DA, Norsworthy KJ, Kern SJ, et al. A meta-analysis of N-acetylcysteine in contrast-induced nephrotoxicity: unsupervised clustering to resolve heterogeneity. *BMC Med*. 2007;5:32. Published online November 14, 2007. doi:10.1186/1741-7015-5-32.
128. Ozcan EE, Guner S, Akdeniz B, et al. Sodium bicarbonate, N-acetylcysteine, and saline for prevention of radiocontrast-induced nephropathy. A comparison of 3 regimens for protecting contrast-induced nephropathy in patients undergoing coronary procedures. A single-center prospective controlled trial. *Am Heart J*. 2007;154:539–44.
129. Thiele H, Hildebrand L, Schirdewahn C, et al. Impact of high-dose N-acetylcysteine versus placebo on contrast-induced nephropathy and myocardial reperfusion injury in unselected patients with ST-segment elevation myocardial infarction undergoing primary percutaneous coronary intervention: the LIPSIA-N-ACC (Prospective, Single-Blind, Placebo-Controlled, Randomized Leipzig Immediate Percutaneous Coronary Intervention Acute Myocardial Infarction N-ACC) Trial. *J Am Coll Cardiol*. 2010;55:2201–9.
130. Webb JG, Pate GE, Humphries KH, et al. A randomized controlled trial of intravenous N-acetylcysteine for the prevention of contrast-induced nephropathy after cardiac catheterization: lack of effect. *Am Heart J*. 2004;148:422–9.
131. ACT Investigators. Acetylcysteine for prevention of renal outcomes in patients undergoing coronary and peripheral vascular angiography: main results from the randomized Acetylcysteine for Contrast-Induced Nephropathy Trial (ACT). *Circulation*. 2011;124:1250–9.
132. Klein LW, Sheldon MW, Brinker J, et al. The use of radiographic contrast media during PCI: a focused review: a position statement of the Society of Cardiovascular Angiography and Interventions. *Catheter Cardiovasc Interv*. 2009;74:728–46.
133. Levine GN, Kern MJ, Berger PB, et al. Management of patients undergoing percutaneous coronary revascularization. *Ann Intern Med*. 2003;139:123–36.
134. Tramer MR, von Elm E, Loubeyre P, et al. Pharmacological prevention of serious anaphylactic reactions due to iodinated contrast media: systematic review. *BMJ*. 2006;333:675.
135. Greenberger PA, Patterson R, Tapio CM. Prophylaxis against repeated radiocontrast media reactions in 857 cases. Adverse experience with cimetidine and safety of beta-adrenergic antagonists. *Arch Intern Med*. 1985;145:2197–200.
136. Shehadi WH. Adverse reactions to intravascularly administered contrast media. A comprehensive study based on a prospective survey. *Am J Roentgenol Radium Ther Nucl Med*. 1975;124:145–52.
137. Gill BV, Rice TR, Cartier A, et al. Identification of crab proteins that elicit IgE reactivity in snow crab-processing workers. *J Allergy Clin Immunol*. 2009;124:1055–61.
138. Swoboda I, Bugajska-Schretter A, Verdino P, et al. Recombinant carp parvalbumin, the major cross-reactive fish allergen: a tool for diagnosis and therapy of fish allergy. *J Immunol*. 2002;168:4576–84.
139. Briguori C, Colombo A, Airolidi F, et al. Statin administration before percutaneous coronary intervention: impact on periprocedural myocardial infarction. *Eur Heart J*. 2004;25:1822–8.
140. Briguori C, Visconti G, Focaccio A, et al. Novel approaches for preventing or limiting events (Naples) II trial: impact of a single high loading dose of atorvastatin on periprocedural myocardial infarction. *J Am Coll Cardiol*. 2009;54:2157–63.
141. Pasceri V, Patti G, Nusca A, et al. Randomized trial of atorvastatin for reduction of myocardial damage during coronary intervention: results from the ARMYDA (Atorvastatin for Reduction of MYocardial Damage during Angioplasty) study. *Circulation*. 2004;110:674–8.
142. Patti G, Pasceri V, Colonna G, et al. Atorvastatin pretreatment improves outcomes in patients with acute coronary syndromes undergoing early percutaneous coronary intervention: results of the ARMYDA-ACS randomized trial. *J Am Coll Cardiol*. 2007;49:1272–8.
143. Yun KH, Jeong MH, Oh SK, et al. The beneficial effect of high loading dose of rosuvastatin before percutaneous coronary intervention in patients with acute coronary syndrome. *Int J Cardiol*. 2009;137:246–51.
144. Zhang F, Dong L, Ge J. Effect of statins pretreatment on periprocedural myocardial infarction in patients undergoing percutaneous coronary intervention: a meta-analysis. *Ann Med*. 2010;42:171–7.
145. Winchester DE, Wen X, Xie L, et al. Evidence of pre-procedural statin therapy: a meta-analysis of randomized trials. *J Am Coll Cardiol*. 2010;56:1099–109.
146. Di Sciascio G, Patti G, Pasceri V, et al. Efficacy of atorvastatin reload in patients on chronic statin therapy undergoing percutaneous coronary intervention: results of the ARMYDA-RECAPTURE (Atorvastatin for Reduction of Myocardial Damage During Angioplasty) Randomized Trial. *J Am Coll Cardiol*. 2009;54:558–65.
147. Levey AS, Coresh J, Greene T, et al. Using standardized serum creatinine values in the modification of diet in renal disease study equation for estimating glomerular filtration rate. *Ann Intern Med*. 2006;145:247–54.
148. Stevens LA, Nolin TD, Richardson MM, et al. Comparison of drug dosing recommendations based on measured GFR and kidney function estimating equations. *Am J Kidney Dis*. 2009;54:33–42.
149. Hassan Y, Al-Ramahi RJ, Aziz NA, et al. Impact of a renal drug dosing service on dose adjustment in hospitalized patients with chronic kidney disease. *Ann Pharmacother*. 2009;43:1598–605.
150. Barnathan ES, Schwartz JS, Taylor L, et al. Aspirin and dipyridamole in the prevention of acute coronary thrombosis complicating coronary angioplasty. *Circulation*. 1987;76:125–34.
151. Jolly SS, Pogue J, Haladyn K, et al. Effects of aspirin dose on ischaemic events and bleeding after percutaneous coronary intervention: insights from the PCI-CURE study. *Eur Heart J*. 2009;30:900–7.
152. Popma JJ, Berger P, Ohman EM, et al. Antithrombotic therapy during percutaneous coronary intervention: the Seventh ACCP Conference on Antithrombotic and Thrombolytic Therapy. *Chest*. 2004;126 Suppl 3:576S–99S.
153. Schwartz L, Bourassa MG, Lesperance J, et al. Aspirin and dipyridamole in the prevention of restenosis after percutaneous transluminal coronary angioplasty. *N Engl J Med*. 1988;318:1714–9.
154. Deleted in proof.
155. Aversano T, Aversano LT, Passamani E, et al. Thrombolytic therapy vs primary percutaneous coronary intervention for myocardial infarction in patients presenting to hospitals without on-site cardiac surgery: a randomized controlled trial. *JAMA*. 2002;287:1943–51.
156. Dehmer GJ, Blankenship J, Wharton TP Jr., et al. The current status and future direction of percutaneous coronary intervention without on-site surgical backup: an expert consensus document from the Society for Cardiovascular Angiography and Interventions. *Catheter Cardiovasc Interv*. 2007;69:471–8.
157. Melberg T, Nilsen DW, Larsen AI, et al. Nonemergent coronary angioplasty without on-site surgical backup: a randomized study

- evaluating outcomes in low-risk patients. *Am Heart J*. 2006;152:888–95.
158. Singh PP, Singh M, Bedi US, et al. Outcomes of nonemergent percutaneous coronary intervention with and without on-site surgical backup: a meta-analysis. *Am J Ther*. 2011;18:e22–8.
159. Brueck M, Bandorski D, Kramer W, et al. A randomized comparison of transradial versus transfemoral approach for coronary angiography and angioplasty. *J Am Coll Cardiol Interv*. 2009;2:1047–54.
160. Jaffe R, Hong T, Sharieff W, et al. Comparison of radial versus femoral approach for percutaneous coronary interventions in octogenarians. *Catheter Cardiovasc Interv*. 2007;69:815–20.
161. Jolly SS, Amlani S, Hamon M, et al. Radial versus femoral access for coronary angiography or intervention and the impact on major bleeding and ischemic events: a systematic review and meta-analysis of randomized trials. *Am Heart J*. 2009;157:132–40.
162. Louvard Y, Benamer H, Garot P, et al. Comparison of transradial and transfemoral approaches for coronary angiography and angioplasty in octogenarians (the OCTOPLUS study). *Am J Cardiol*. 2004;94:1177–80.
163. Pristipino C, Trani C, Nazzaro MS, et al. Major improvement of percutaneous cardiovascular procedure outcomes with radial artery catheterisation: results from the PREVAIL study. *Heart*. 2009;95:476–82.
164. Rao SV, Ou FS, Wang TY, et al. Trends in the prevalence and outcomes of radial and femoral approaches to percutaneous coronary intervention: a report from the National Cardiovascular Data Registry. *J Am Coll Cardiol Interv*. 2008;1:379–86.
165. Rao SV, Cohen MG, Kandzari DE, et al. The transradial approach to percutaneous coronary intervention: historical perspective, current concepts, and future directions. *J Am Coll Cardiol*. 2010;55:2187–95.
166. Hamon M, Rasmussen LH, Manoukian SV, et al. Choice of arterial access site and outcomes in patients with acute coronary syndromes managed with an early invasive strategy: the ACUITY trial. *Euro-Intervention*. 2009;5:115–20.
167. Jolly SS, Yusuf S, Cairns J, et al. Radial versus femoral access for coronary angiography and intervention in patients with acute coronary syndromes (RIVAL): a randomised, parallel group, multicentre trial. *Lancet*. 2011;377:1409–20.
168. Bavry AA, Kumbhani DJ, Rassi AN, et al. Benefit of early invasive therapy in acute coronary syndromes: a meta-analysis of contemporary randomized clinical trials. *J Am Coll Cardiol*. 2006;48:1319–25.
169. Cannon CP, Weintraub WS, Demopoulos LA, et al. Comparison of early invasive and conservative strategies in patients with unstable coronary syndromes treated with the glycoprotein IIb/IIIa inhibitor tirofiban. *N Engl J Med*. 2001;344:1879–87.
170. Fox KA, Clayton TC, Damman P, et al. Long-term outcome of a routine versus selective invasive strategy in patients with non-ST-segment elevation acute coronary syndrome: a meta-analysis of individual patient data. *J Am Coll Cardiol*. 2010;55:2435–45.
171. FRagmin and Fast Revascularisation during Instability in Coronary artery disease Investigators. Invasive compared with non-invasive treatment in unstable coronary-artery disease: FRISC II prospective randomised multicentre study. *Lancet*. 1999;354:708–15.
172. Mehta SR, Granger CB, Boden WE, et al. Early versus delayed invasive intervention in acute coronary syndromes. *N Engl J Med*. 2009;360:2165–75.
173. Rodriguez AE, Baldi J, Fernandez PC, et al. Five-year follow-up of the Argentine randomized trial of coronary angioplasty with stenting versus coronary bypass surgery in patients with multiple vessel disease (ERACI II). *J Am Coll Cardiol*. 2005;46:582–8.
174. Valgimigli M, Dawkins K, Macaya C, et al. Impact of stable versus unstable coronary artery disease on 1-year outcome in elective patients undergoing multivessel revascularization with sirolimus-eluting stents: a subanalysis of the ARTS II trial. *J Am Coll Cardiol*. 2007;49:431–41.
175. Keeley EC, Boura JA, Grines CL. Primary angioplasty versus intravenous thrombolytic therapy for acute myocardial infarction: a quantitative review of 23 randomised trials. *Lancet*. 2003;361:13–20.
176. Zijlstra F, de Boer MJ, Hoorntje JC, et al. A comparison of immediate coronary angioplasty with intravenous streptokinase in acute myocardial infarction. *N Engl J Med*. 1993;328:680–4.
177. Keeley EC, Grines CL. Primary coronary intervention for acute myocardial infarction. *JAMA*. 2004;291:736–9.
178. Keeley EC, Hillis LD. Primary PCI for myocardial infarction with ST-segment elevation. *N Engl J Med*. 2007;356:47–54.
179. Wu AH, Parsons L, Every NR, et al. Hospital outcomes in patients presenting with congestive heart failure complicating acute myocardial infarction: a report from the Second National Registry of Myocardial Infarction (NORMI-2). *J Am Coll Cardiol*. 2002;40:1389–94.
180. Hochman JS, Sleeper LA, Webb JG, et al., SHOCK Investigators. Early revascularization in acute myocardial infarction complicated by cardiogenic shock. Should We Emergently Revascularize Occluded Coronaries for Cardiogenic Shock. *N Engl J Med*. 1999;341:625–34.
181. Gershlick AH, Stephens-Lloyd A, Hughes S, et al. Rescue angioplasty after failed thrombolytic therapy for acute myocardial infarction. *N Engl J Med*. 2005;353:2758–68.
182. Wijeyesundera HC, Vijayaraghavan R, Nallamothu BK, et al. Rescue angioplasty or repeat fibrinolysis after failed fibrinolytic therapy for ST-segment myocardial infarction: a meta-analysis of randomized trials. *J Am Coll Cardiol*. 2007;49:422–30.
183. Bohmer E, Hoffmann P, Abdelnoor M, et al. Efficacy and safety of immediate angioplasty versus ischemia-guided management after thrombolysis in acute myocardial infarction in areas with very long transfer distances results of the NORDISTEMI (NORwegian study on DIstrict treatment of ST-elevation myocardial infarction). *J Am Coll Cardiol*. 2010;55:102–10.
184. Di Mario C, Dudek D, Piscione F, et al. Immediate angioplasty versus standard therapy with rescue angioplasty after thrombolysis in the Combined Abciximab REteplase Stent Study in Acute Myocardial Infarction (CARESS-in-AMI): an open, prospective, randomised, multicentre trial. *Lancet*. 2008;371:559–68.
185. Fernandez-Aviles F, Alonso JJ, Castro-Beiras A, et al. Routine invasive strategy within 24 hours of thrombolysis versus ischaemia-guided conservative approach for acute myocardial infarction with ST-segment elevation (GRACIA-1): a randomised controlled trial. *Lancet*. 2004;364:1045–53.
186. Borgia F, Goodman SG, Halvorsen S, et al. Early routine percutaneous coronary intervention after fibrinolysis vs standard therapy in ST-segment elevation myocardial infarction: a meta-analysis. *Eur Heart J*. 2010;31:2156–69.
187. Cantor WJ, Fitchett D, Borgundvaag B, et al. Routine early angioplasty after fibrinolysis for acute myocardial infarction. *N Engl J Med*. 2009;360:2705–18.
188. Lambert L, Brown K, Segal E, et al. Association between timeliness of reperfusion therapy and clinical outcomes in ST-elevation myocardial infarction. *JAMA*. 2010;303:2148–55.
189. Terkelsen CJ, Sorensen JT, Maeng M, et al. System delay and mortality among patients with STEMI treated with primary percutaneous coronary intervention. *JAMA*. 2010;304:763–71.
190. Aguirre FV, Varghese JJ, Kelley MP, et al. Rural interhospital transfer of ST-elevation myocardial infarction patients for percutaneous coronary revascularization: the Stat Heart Program. *Circulation*. 2008;117:1145–52.
191. Blankenship JC, Scott TD, Skelding KA, et al. Door-to-balloon times under 90 min can be routinely achieved for patients transferred for ST-segment elevation myocardial infarction percutaneous coronary intervention in a rural setting. *J Am Coll Cardiol*. 2011;57:272–9.
192. Henry TD, Sharkey SW, Burke MN, et al. A regional system to provide timely access to percutaneous coronary intervention for ST-elevation myocardial infarction. *Circulation*. 2007;116:721–8.
193. Zahn R, Schuster S, Schiele R, et al., Maximal Individual Therapy in Acute Myocardial Infarction (MITRA) Study Group. Comparison of primary angioplasty with conservative therapy in patients with acute myocardial infarction and contraindications for thrombolytic therapy. *Catheter Cardiovasc Interv*. 1999;46:127–33.
194. Grzybowski M, Clements EA, Parsons L, et al. Mortality benefit of immediate revascularization of acute ST-segment elevation myocardial infarction in patients with contraindications to thrombolytic therapy: a propensity analysis. *JAMA*. 2003;290:1891–8.
195. Fibrinolytic Therapy Trialists' (FTT) Collaborative Group. Indications for fibrinolytic therapy in suspected acute myocardial infarction: collaborative overview of early mortality and major morbidity results from all randomised trials of more than 1000 patients. *Lancet*. 1994;343:311–22.
196. Schomig A, Mehilli J, Antoniucci D, et al. Mechanical reperfusion in patients with acute myocardial infarction presenting more than 12



- hours from symptom onset: a randomized controlled trial. *JAMA*. 2005;293:2865–72.
197. Gierlotka M, Gasior M, Wilczek K, et al. Reperfusion by primary percutaneous coronary intervention in patients with ST-segment elevation myocardial infarction within 12 to 24 hours of the onset of symptoms (from a prospective national observational study [PL-ACS]). *Am J Cardiol*. 2011;107:501–8.
198. Toma M, Buller CE, Westerhout CM, et al. Non-culprit coronary artery percutaneous coronary intervention during acute ST-segment elevation myocardial infarction: insights from the APEX-AMI trial. *Eur Heart J*. 2010;31:1701–7.
199. Widimsky P, Holmes DR Jr. How to treat patients with ST-elevation acute myocardial infarction and multi-vessel disease? *Eur Heart J*. 2011;32:396–403.
200. Politi L, Sgura F, Rossi R, et al. A randomised trial of target-vessel versus multi-vessel revascularisation in ST-elevation myocardial infarction: major adverse cardiac events during long-term follow-up. *Heart*. 2010;96:662–7.
201. Vlaar PJ, Mahmoud KD, Holmes DR Jr., et al. Culprit vessel only versus multivessel and staged percutaneous coronary intervention for multivessel disease in patients presenting with ST-segment elevation myocardial infarction: a pairwise and network meta-analysis. *J Am Coll Cardiol*. 2011;58:692–703.
202. Kornowski R, Mehran R, Dangas G, et al. Prognostic impact of staged versus “one-time” multivessel percutaneous interventions in acute myocardial infarction: analysis from the HORIZONS-AMI trial. *J Am Coll Cardiol*. 2011;58:704–11.
203. Erne P, Schoenenberger AW, Burckhardt D, et al. Effects of percutaneous coronary interventions in silent ischemia after myocardial infarction: the SWISSI II randomized controlled trial. *JAMA*. 2007;297:1985–91.
204. Madsen JK, Grande P, Saunamaki K, et al. Danish multicenter randomized study of invasive versus conservative treatment in patients with inducible ischemia after thrombolysis in acute myocardial infarction (DANAMI). DANish trial in Acute Myocardial Infarction. *Circulation*. 1997;96:748–55.
205. Stenestrand U, Wallentin L. Early revascularisation and 1-year survival in 14-day survivors of acute myocardial infarction: a prospective cohort study. *Lancet*. 2002;359:1805–11.
206. Alter DA, Tu JV, Austin PC, et al. Waiting times, revascularization modality, and outcomes after acute myocardial infarction at hospitals with and without on-site revascularization facilities in Canada. *J Am Coll Cardiol*. 2003;42:410–9.
207. Zeymer U, Uebis R, Vogt A, et al. Randomized comparison of percutaneous transluminal coronary angioplasty and medical therapy in stable survivors of acute myocardial infarction with single vessel disease: a study of the Arbeitsgemeinschaft Leitende Kardiologische Krankenhausärzte. *Circulation*. 2003;108:1324–8.
208. Gupta M, Chang WC, Van de Werf F, et al. International differences in in-hospital revascularization and outcomes following acute myocardial infarction: a multilevel analysis of patients in ASSENT-2. *Eur Heart J*. 2003;24:1640–50.
209. Gibson CM, Karha J, Murphy SA, et al. Early and long-term clinical outcomes associated with reinfarction following fibrinolytic administration in the Thrombolysis in Myocardial Infarction trials. *J Am Coll Cardiol*. 2003;42:7–16.
210. Ioannidis JP, Katritsis DG. Percutaneous coronary intervention for late reperfusion after myocardial infarction in stable patients. *Am Heart J*. 2007;154:1065–71.
211. Steg PG, Thuair C, Himbert D, et al. DECOPI (DEobstruction Coronaire en Post-Infarctus): a randomized multi-centre trial of occluded artery angioplasty after acute myocardial infarction. *Eur Heart J*. 2004;25:2187–94.
212. Hochman JS, Lamas GA, Buller CE, et al. Coronary intervention for persistent occlusion after myocardial infarction. *N Engl J Med*. 2006;355:2395–407.
213. Hochman JS, Sleeper LA, White HD, et al. One-year survival following early revascularization for cardiogenic shock. *JAMA*. 2001;285:190–2.
214. Hochman JS, Sleeper LA, Webb JG, et al. Early revascularization and long-term survival in cardiogenic shock complicating acute myocardial infarction. *JAMA*. 2006;295:2511–5.
215. Urban P, Stauffer JC, Bleed D, et al. A randomized evaluation of early revascularization to treat shock complicating acute myocardial infarction. The (Swiss) Multicenter Trial of Angioplasty for Shock-(S)MASH. *Eur Heart J*. 1999;20:1030–8.
216. Sanborn TA, Sleeper LA, Bates ER, et al. Impact of thrombolysis, intra-aortic balloon pump counterpulsation, and their combination in cardiogenic shock complicating acute myocardial infarction: a report from the SHOCK Trial Registry. SHould we emergently revascularize Occluded Coronaries for cardiogenic shock? *J Am Coll Cardiol*. 2000;36:1123–9.
217. Chen EW, Canto JG, Parsons LS, et al. Relation between hospital intra-aortic balloon counterpulsation volume and mortality in acute myocardial infarction complicated by cardiogenic shock. *Circulation*. 2003;108:951–7.
218. Barron HV, Every NR, Parsons LS, et al. The use of intra-aortic balloon counterpulsation in patients with cardiogenic shock complicating acute myocardial infarction: data from the National Registry of Myocardial Infarction 2. *Am Heart J*. 2001;141:933–9.
219. Reynolds HR, Hochman JS. Cardiogenic shock: current concepts and improving outcomes. *Circulation*. 2008;117:686–97.
220. Berger PB, Bell MR, Hasdai D, et al. Safety and efficacy of ticlopidine for only 2 weeks after successful intracoronary stent placement. *Circulation*. 1999;99:248–53.
221. Cruden NL, Harding SA, Flapan AD, et al. Previous coronary stent implantation and cardiac events in patients undergoing noncardiac surgery. *Circ Cardiovasc Interv*. 2010;3:236–42.
222. Fleisher LA, Beckman JA, Brown KA, et al. 2009 ACCF/AHA focused update on perioperative beta blockade incorporated into the ACC/AHA 2007 guidelines on perioperative cardiovascular evaluation and care for noncardiac surgery. *J Am Coll Cardiol*. 2009;54:e13–118.
223. Kaluza GL, Joseph J, Lee JR, et al. Catastrophic outcomes of noncardiac surgery soon after coronary stenting. *J Am Coll Cardiol*. 2000;35:1288–94.
224. Reddy PR, Vaitkus PT. Risks of noncardiac surgery after coronary stenting. *Am J Cardiol*. 2005;95:755–7.
225. Sharma AK, Ajani AE, Hamwi SM, et al. Major noncardiac surgery following coronary stenting: when is it safe to operate? *Catheter Cardiovasc Interv*. 2004;63:141–5.
226. Wilson SH, Fasseas P, Orford JL, et al. Clinical outcome of patients undergoing non-cardiac surgery in the two months following coronary stenting. *J Am Coll Cardiol*. 2003;42:234–40.
227. Fleisher LA, Beckman JA, Brown KA, et al. ACC/AHA 2007 guidelines on perioperative cardiovascular evaluation and care for noncardiac surgery: executive summary: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Writing Committee to Revise the 2002 Guidelines on Perioperative Cardiovascular Evaluation for Noncardiac Surgery). *J Am Coll Cardiol*. 2007;50:1707–32.
228. McFalls EO, Ward HB, Moritz TE, et al. Coronary-artery revascularization before elective major vascular surgery. *N Engl J Med*. 2004;351:2795–804.
229. Schouten O, van Kuijk JP, Flu WJ, et al. Long-term outcome of prophylactic coronary revascularization in cardiac high-risk patients undergoing major vascular surgery (from the randomized DECREASE-V Pilot Study). *Am J Cardiol*. 2009;103:897–901.
230. Kaluza GL, Joseph J, Lee JR, et al. Catastrophic outcomes of noncardiac surgery soon after coronary stenting. *J Am Coll Cardiol*. 2000;35:1288–94.
231. Win HK, Caldera AE, Maresh K, et al. Clinical outcomes and stent thrombosis following off-label use of drug-eluting stents. *JAMA*. 2007;297:2001–9.
232. Eisenstein EL, Anstrom KJ, Kong DF, et al. Clopidogrel use and long-term clinical outcomes after drug-eluting stent implantation. *JAMA*. 2007;297:159–68.
233. Moses JW, Leon MB, Popma JJ, et al. Sirolimus-eluting stents versus standard stents in patients with stenosis in a native coronary artery. *N Engl J Med*. 2003;349:1315–23.
234. Stone GW, Ellis SG, Cox DA, et al. One-year clinical results with the slow-release, polymer-based, paclitaxel-eluting TAXUS stent: the TAXUS-IV trial. *Circulation*. 2004;109:1942–7.
235. Mauri L, Silbaugh TS, Garg P, et al. Drug-eluting or bare-metal stents for acute myocardial infarction. *N Engl J Med*. 2008;359:1330–42.
236. Stone GW, Lansky AJ, Pocock SJ, et al. Paclitaxel-eluting stents versus bare-metal stents in acute myocardial infarction. *N Engl J Med*. 2009;360:1946–59.



237. Mehilli J, Pache J, Abdel-Wahab M, et al. Drug-eluting versus bare-metal stents in saphenous vein graft lesions (ISAR-CABG): a randomised controlled superiority trial. *Lancet*, published online before print August 28, 2011, doi:10.1016/S0140-6736(11)61255-5.
238. Pan XH, Chen YX, Xiang MX, et al. A meta-analysis of randomized trials on clinical outcomes of paclitaxel-eluting stents versus bare-metal stents in ST-segment elevation myocardial infarction patients. *J Zhejiang Univ Sci B*. 2010;11:754–61.
239. Hao PP, Chen YG, Wang XL, et al. Efficacy and safety of drug-eluting stents in patients with acute ST-segment-elevation myocardial infarction: a meta-analysis of randomized controlled trials. *Tex Heart Inst J*. 2010;37:516–24.
240. Suh HS, Song HJ, Choi JE, et al. Drug-eluting stents versus bare-metal stents in acute myocardial infarction: a systematic review and meta-analysis. *Int J Technol Assess Health Care*. 2011;27:11–22.
241. Park DW, Park SW, Park KH, et al. Frequency of and risk factors for stent thrombosis after drug-eluting stent implantation during long-term follow-up. *Am J Cardiol*. 2006;98:352–6.
242. Spertus JA, Kettelkamp R, Vance C, et al. Prevalence, predictors, and outcomes of premature discontinuation of thienopyridine therapy after drug-eluting stent placement: results from the PREMIER registry. *Circulation*. 2006;113:2803–9.
243. Nasser M, Kapeliovich M, Markiewicz W. Late thrombosis of sirolimus-eluting stents following noncardiac surgery. *Catheter Cardiovasc Interv*. 2005;65:516–9.
244. Hamilos M, Muller O, Cuisset T, et al. Long-term clinical outcome after fractional flow reserve-guided treatment in patients with angiographically equivocal left main coronary artery stenosis. *Circulation*. 2009;120:1505–12.
245. Pijls NH, van Schaardenburgh P, Manoharan G, et al. Percutaneous coronary intervention of functionally nonsignificant stenosis: 5-year follow-up of the DEFER Study. *J Am Coll Cardiol*. 2007;49:2105–11.
246. Pijls NH, Fearon WF, Tonino PA, et al. Fractional flow reserve versus angiography for guiding percutaneous coronary intervention in patients with multivessel coronary artery disease: 2-year follow-up of the FAME (Fractional Flow Reserve Versus Angiography for Multivessel Evaluation) study. *J Am Coll Cardiol*. 2010;56:177–84.
247. Tonino PA, Fearon WF, De Bruyne B, et al. Angiographic versus functional severity of coronary artery stenoses in the FAME study fractional flow reserve versus angiography in multivessel evaluation. *J Am Coll Cardiol*. 2010;55:2816–21.
248. Briguori C, Anzuini A, Airolidi F, et al. Intravascular ultrasound criteria for the assessment of the functional significance of intermediate coronary artery stenoses and comparison with fractional flow reserve. *Am J Cardiol*. 2001;87:136–41.
249. Fassa AA, Wagatsuma K, Higano ST, et al. Intravascular ultrasound-guided treatment for angiographically indeterminate left main coronary artery disease: a long-term follow-up study. *J Am Coll Cardiol*. 2005;45:204–11.
250. Kang SJ, Lee JY, Ahn JM, et al. Validation of intravascular ultrasound-derived parameters with fractional flow reserve for assessment of coronary stenosis severity. *Circ Cardiovasc Interv*. 2011;4:65–71.
251. Costanzo MR, Dipchand A, Starling R, et al. The International Society of Heart and Lung Transplantation Guidelines for the care of heart transplant recipients. *J Heart Lung Transplant*. 2010;29:914–56.
252. Kobashigawa JA, Tobis JM, Starling RC, et al. Multicenter intravascular ultrasound validation study among heart transplant recipients: outcomes after five years. *J Am Coll Cardiol*. 2005;45:1532–7.
253. Kapadia SR, Nissen SE, Ziada KM, et al. Development of transplantation vasculopathy and progression of donor-transmitted atherosclerosis: comparison by serial intravascular ultrasound imaging. *Circulation*. 1998;98:2672–8.
254. Dargas GD, Claessen BE, Caixeta A, et al. In-stent restenosis in the drug-eluting stent era. *J Am Coll Cardiol*. 2010;56:1897–907.
255. Takagi A, Tsurumi Y, Ishii Y, et al. Clinical potential of intravascular ultrasound for physiological assessment of coronary stenosis: relationship between quantitative ultrasound tomography and pressure-derived fractional flow reserve. *Circulation*. 1999;100:250–5.
256. Magni V, Chieffo A, Colombo A. Evaluation of intermediate coronary stenosis with intravascular ultrasound and fractional flow reserve: its use and abuse. *Catheter Cardiovasc Interv*. 2009;73:441–8.
257. Park SJ, Kim YH, Park DW, et al. Impact of intravascular ultrasound guidance on long-term mortality in stenting for unprotected left main coronary artery stenosis. *Circ Cardiovasc Interv*. 2009;2:167–77.
258. Moussa I, Di Mario C, Moses J, et al. Coronary stenting after rotational atherectomy in calcified and complex lesions. Angiographic and clinical follow-up results. *Circulation*. 1997;96:128–36.
259. Vaquerizo B, Serra A, Miranda F, et al. Aggressive plaque modification with rotational atherectomy and/or cutting balloon before drug-eluting stent implantation for the treatment of calcified coronary lesions. *J Interv Cardiol*. 2010;23:240–8.
260. Bittl JA, Chew DP, Topol EJ, et al. Meta-analysis of randomized trials of percutaneous transluminal coronary angioplasty versus atherectomy, cutting balloon atherotomy, or laser angioplasty. *J Am Coll Cardiol*. 2004;43:936–42.
261. Mauri L, Reisman M, Buchbinder M, et al. Comparison of rotational atherectomy with conventional balloon angioplasty in the prevention of restenosis of small coronary arteries: results of the Dilatation vs Ablation Revascularization Trial Targeting Restenosis (DART). *Am Heart J*. 2003;145:847–54.
262. Reifart N, Vandormael M, Krajcar M, et al. Randomized comparison of angioplasty of complex coronary lesions at a single center. Excimer Laser, Rotational Atherectomy, and Balloon Angioplasty Comparison (ERBAC) Study. *Circulation*. 1997;96:91–8.
263. vom Dahl J, Dietz U, Haager PK, et al. Rotational atherectomy does not reduce recurrent in-stent restenosis: results of the angioplasty versus rotational atherectomy for treatment of diffuse in-stent restenosis trial (ARTIST). *Circulation*. 2002;105:583–8.
264. Sardella G, Mancone M, Bucciarelli-Ducci C, et al. Thrombus aspiration during primary percutaneous coronary intervention improves myocardial reperfusion and reduces infarct size: the EXPIRA (thrombectomy with export catheter in infarct-related artery during primary percutaneous coronary intervention) prospective, randomized trial. *J Am Coll Cardiol*. 2009;53:309–15.
265. Vlaar PJ, Svilaas T, van der Horst IC, et al. Cardiac death and reinfarction after 1 year in the Thrombus Aspiration during Percutaneous coronary intervention in Acute myocardial infarction Study (TAPAS): a 1-year follow-up study. *Lancet*. 2008;371:1915–20.
266. Bavry AA, Kumbhani DJ, Bhatt DL. Role of adjunctive thrombectomy and embolic protection devices in acute myocardial infarction: a comprehensive meta-analysis of randomized trials. *Eur Heart J*. 2008;29:2989–3001.
267. Noble S, Bilodeau L. High energy excimer laser to treat coronary in-stent restenosis in an underexpanded stent. *Catheter Cardiovasc Interv*. 2008;71:803–7.
268. Stone GW, de Marchena E, Dageforde D, et al., The Laser Angioplasty Versus Angioplasty (LAVA) Trial Investigators. Prospective, randomized, multicenter comparison of laser-facilitated balloon angioplasty versus stand-alone balloon angioplasty in patients with obstructive coronary artery disease. *J Am Coll Cardiol*. 1997;30:1714–21.
269. Albiero R, Silber S, Di Mario C, et al. Cutting balloon versus conventional balloon angioplasty for the treatment of in-stent restenosis: results of the restenosis cutting balloon evaluation trial (RESCUT). *J Am Coll Cardiol*. 2004;43:943–9.
270. Mauri L, Bonan R, Weiner BH, et al. Cutting balloon angioplasty for the prevention of restenosis: results of the Cutting Balloon Global Randomized Trial. *Am J Cardiol*. 2002;90:1079–83.
271. Baim DS, Wahr D, George B, et al. Randomized trial of a distal embolic protection device during percutaneous intervention of saphenous vein aorto-coronary bypass grafts. *Circulation*. 2002;105:1285–90.
272. Coolong A, Baim DS, Kuntz RE, et al. Saphenous vein graft stenting and major adverse cardiac events: a predictive model derived from a pooled analysis of 3958 patients. *Circulation*. 2008;117:790–7.
273. Mauri L, Cox D, Hermiller J, et al. The PROXIMAL trial: proximal protection during saphenous vein graft intervention using the Proxis Embolic Protection System: a randomized, prospective, multicenter clinical trial. *J Am Coll Cardiol*. 2007;50:1442–9.
274. Stone GW, Rogers C, Hermiller J, et al. Randomized comparison of distal protection with a filter-based catheter and a balloon occlusion and aspiration system during percutaneous intervention of diseased saphenous vein aorto-coronary bypass grafts. *Circulation*. 2003;108:548–53.

275. Schomig A, Neumann FJ, Kastrati A, et al. A randomized comparison of antiplatelet and anticoagulant therapy after the placement of coronary-artery stents. *N Engl J Med*. 1996;334:1084–9.
276. Collaborative meta-analysis of randomised trials of antiplatelet therapy for prevention of death, myocardial infarction, and stroke in high risk patients. *BMJ*. 2002;324:71–86.
277. Smith SC Jr., Allen J, Blair SN, et al. AHA/ACC guidelines for secondary prevention for patients with coronary and other atherosclerotic vascular disease. *J Am Coll Cardiol*. 2006;47:2130–9.
278. Baigent C, Blackwell L, Collins R, et al. Aspirin in the primary and secondary prevention of vascular disease: collaborative meta-analysis of individual participant data from randomised trials. *Lancet*. 2009;373:1849–60.
279. Gurbel PA, Bliden KP, Zaman KA, et al. Clopidogrel loading with eptifibatide to arrest the reactivity of platelets: results of the Clopidogrel Loading With Eptifibatide to Arrest the Reactivity of Platelets (CLEAR PLATELETS) study. *Circulation*. 2005;111:1153–9.
280. Sabatine MS, Cannon CP, Gibson CM, et al. Effect of clopidogrel pretreatment before percutaneous coronary intervention in patients with ST-elevation myocardial infarction treated with fibrinolytics: the PCI-CLARITY study. *JAMA*. 2005;294:1224–32.
281. van der Heijden DJ, Westendorp IC, Riezebos RK, et al. Lack of efficacy of clopidogrel pre-treatment in the prevention of myocardial damage after elective stent implantation. *J Am Coll Cardiol*. 2004;44:20–4.
282. Wiviott SD, Braunwald E, McCabe CH, et al. Prasugrel versus clopidogrel in patients with acute coronary syndromes. *N Engl J Med*. 2007;357:2001–15.
283. Wallentin L, Becker RC, Budaj A, et al. Ticagrelor versus clopidogrel in patients with acute coronary syndromes. *N Engl J Med*. 2009;361:1045–57.
284. Chen ZM, Jiang LX, Chen YP, et al. Addition of clopidogrel to aspirin in 45,852 patients with acute myocardial infarction: randomised placebo-controlled trial. *Lancet*. 2005;366:1607–21.
285. Mehta SR, Yusuf S, Peters RJ, et al. Effects of pretreatment with clopidogrel and aspirin followed by long-term therapy in patients undergoing percutaneous coronary intervention: the PCI-CURE study. *Lancet*. 2001;358:527–33.
286. Brar SS, Kim J, Brar SK, et al. Long-term outcomes by clopidogrel duration and stent type in a diabetic population with de novo coronary artery lesions. *J Am Coll Cardiol*. 2008;51:2220–7.
287. Steinhubl SR, Berger PB, Mann JTI, et al. Early and sustained dual oral antiplatelet therapy following percutaneous coronary intervention: a randomized controlled trial. *JAMA*. 2002;288:2411–20.
288. Patrono C, Baigent C, Hirsh J, et al. Antiplatelet drugs: American College of Chest Physicians Evidence-Based Clinical Practice Guidelines (8th edition). *Chest*. 2008;133:199S–233S.
289. Steinhubl SR, Bhatt DL, Brennan DM, et al. Aspirin to prevent cardiovascular disease: the association of aspirin dose and clopidogrel with thrombosis and bleeding. *Ann Intern Med*. 2009;150:379–86.
290. Serebruany VL, Steinhubl SR, Berger PB, et al. Analysis of risk of bleeding complications after different doses of aspirin in 192,036 patients enrolled in 31 randomized controlled trials. *Am J Cardiol*. 2005;95:1218–22.
291. Peters RJ, Mehta SR, Fox KA, et al. Effects of aspirin dose when used alone or in combination with clopidogrel in patients with acute coronary syndromes: observations from the Clopidogrel in Unstable angina to prevent Recurrent Events (CURE) study. *Circulation*. 2003;108:1682–7.
292. Antoniucci D, Migliorini A, Parodi G, et al. Abciximab-supported infarct artery stent implantation for acute myocardial infarction and long-term survival: a prospective, multicenter, randomized trial comparing infarct artery stenting plus abciximab with stenting alone. *Circulation*. 2004;109:1704–6.
293. Neumann FJ, Kastrati A, Schmitt C, et al. Effect of glycoprotein IIb/IIIa receptor blockade with abciximab on clinical and angiographic restenosis rate after the placement of coronary stents following acute myocardial infarction. *J Am Coll Cardiol*. 2000;35:915–21.
294. Stone GW, Grines CL, Cox DA, et al. Comparison of angioplasty with stenting, with or without abciximab, in acute myocardial infarction. *N Engl J Med*. 2002;346:957–66.
295. Montalescot G, Barragan P, Wittenberg O, et al. Platelet glycoprotein IIb/IIIa inhibition with coronary stenting for acute myocardial infarction. *N Engl J Med*. 2001;344:1895–903.
296. De Luca G, Suryapranata H, Stone GW, et al. Abciximab as adjunctive therapy to reperfusion in acute ST-segment elevation myocardial infarction: a meta-analysis of randomized trials. *JAMA*. 2005;293:1759–65.
297. Mehilli J, Kastrati A, Schulz S, et al. Abciximab in patients with acute ST-segment-elevation myocardial infarction undergoing primary percutaneous coronary intervention after clopidogrel loading: a randomized double-blind trial. *Circulation*. 2009;119:1933–40.
298. De Luca G, Navarese E, Marino P. Risk profile and benefits from Gp IIb-IIIa inhibitors among patients with ST-segment elevation myocardial infarction treated with primary angioplasty: a meta-regression analysis of randomized trials. *Eur Heart J*. 2009;30:2705–13.
299. Bellandi F, Maioli M, Gallopin M, et al. Increase of myocardial salvage and left ventricular function recovery with intracoronary abciximab downstream of the coronary occlusion in patients with acute myocardial infarction treated with primary coronary intervention. *Catheter Cardiovasc Interv*. 2004;62:186–92.
300. Romagnoli E, Burzotta F, Trani C, et al. Angiographic evaluation of the effect of intracoronary abciximab administration in patients undergoing urgent PCI. *Int J Cardiol*. 2005;105:250–5.
301. Iversen A, Galatius S, Jensen JS. The optimal route of administration of the glycoprotein IIb/IIIa receptor antagonist abciximab during percutaneous coronary intervention: intravenous versus intracoronary. *Curr Cardiol Rev*. 2008;4:293–9.
302. Wohrle J, Nusser T, Mayer C, et al. Intracoronary application of abciximab in patients with ST-elevation myocardial infarction. *EuroIntervention*. 2008;3:465–9.
303. Kakkar AK, Moustapha A, Hanley HG, et al. Comparison of intracoronary vs. intravenous administration of abciximab in coronary stenting. *Catheter Cardiovasc Interv*. 2004;61:31–4.
304. Wohrle J, Grebe OC, Nusser T, et al. Reduction of major adverse cardiac events with intracoronary compared with intravenous bolus application of abciximab in patients with acute myocardial infarction or unstable angina undergoing coronary angioplasty. *Circulation*. 2003;107:1840–3.
305. Bertrand OF, Rodes-Cabau J, Larose E, et al. Intracoronary compared to intravenous abciximab and high-dose bolus compared to standard dose in patients with ST-segment elevation myocardial infarction undergoing transradial primary percutaneous coronary intervention: a two-by-two factorial placebo-controlled randomized study. *Am J Cardiol*. 2010;105:1520–7.
306. Deibele AJ, Kirtane AJ, Pinto DS, et al. Intracoronary bolus administration of eptifibatide during percutaneous coronary stenting for non ST elevation myocardial infarction and unstable angina. *J Thromb Thrombolysis*. 2006;22:47–50.
307. Yang XC, Zhang DP, Wang LF, et al. [Effects of intracoronary or intravenous tirofiban administration in patients with acute ST-elevation myocardial infarction undergoing primary percutaneous coronary intervention]. *Zhonghua Xin Xue Guan Bing Za Zhi*. 2007;35:517–22.
308. Deibele AJ, Jennings LK, Tcheng JE, et al. Intracoronary eptifibatide bolus administration during percutaneous coronary revascularization for acute coronary syndromes with evaluation of platelet glycoprotein IIb/IIIa receptor occupancy and platelet function: the Intracoronary Eptifibatide (ICE) Trial. *Circulation*. 2010;121:784–91.
309. Hansen PR, Iversen A, Abdulla J. Improved clinical outcomes with intracoronary compared to intravenous abciximab in patients with acute coronary syndromes undergoing percutaneous coronary intervention: a systematic review and meta-analysis. *J Invasive Cardiol*. 2010;22:278–82.
310. Galache Osuna JG, Sanchez-Rubio J, Calvo I, et al. [Does intracoronary abciximab improve the outcome of percutaneous coronary interventions? A randomized controlled trial]. *Rev Esp Cardiol*. 2006;59:567–74.
311. Wu TG, Zhao Q, Huang WG, et al. Effect of intracoronary tirofiban in patients undergoing percutaneous coronary intervention for acute coronary syndrome. *Circ J*. 2008;72:1605–9.
312. Marciniak SJ Jr., Mascelli MA, Furman MI, et al. An additional mechanism of action of abciximab: dispersal of newly formed platelet aggregates. *Thromb Haemost*. 2002;87:1020–5.
313. Montalescot G, Borentain M, Payot L, et al. Early vs late administration of glycoprotein IIb/IIIa inhibitors in primary percutaneous coronary intervention of acute ST-segment elevation myocardial infarction: a meta-analysis. *JAMA*. 2004;292:362–6.
314. Maioli M, Bellandi F, Leoncini M, et al. Randomized early versus late abciximab in acute myocardial infarction treated with primary



- coronary intervention (RELAX-AMI Trial). *J Am Coll Cardiol*. 2007;49:1517–24.
315. Keeley EC, Boura JA, Grines CL. Comparison of primary and facilitated percutaneous coronary interventions for ST-elevation myocardial infarction: quantitative review of randomised trials. *Lancet*. 2006;367:579–88.
316. van't Hof AWJ, ten Berg JM, Heesterhans T, et al. Prehospital initiation of tirofiban in patients with ST-elevation myocardial infarction undergoing primary angioplasty (On-TIME 2): a multicentre, double-blind, randomised controlled trial. *Lancet*. 2008;372:537–46.
317. ten Berg JM, van't Hof AWJ, Dill T, et al. Effect of early, pre-hospital initiation of high bolus dose tirofiban in patients with ST-segment elevation myocardial infarction on short- and long-term clinical outcome. *J Am Coll Cardiol*. 2010;55:2446–55.
318. Ellis SG, Tendera M, de Belder MA, et al. 1-year survival in a randomized trial of facilitated reperfusion: results from the FINESSE (Facilitated Intervention with Enhanced Reperfusion Speed to Stop Events) trial. *J Am Coll Cardiol Interv*. 2009;2:909–16.
319. Ellis SG, Tendera M, de Belder MA, et al. Facilitated PCI in patients with ST-elevation myocardial infarction. *N Engl J Med*. 2008;358:2205–17.
320. El Khoury C, Dubien PY, Mercier C, et al. Prehospital high-dose tirofiban in patients undergoing primary percutaneous intervention. The AGIR-2 study. *Arch Cardiovasc Dis*. 2010;103:285–92.
321. The EPILOG Investigators. Platelet glycoprotein IIb/IIIa receptor blockade and low-dose heparin during percutaneous coronary revascularization. *N Engl J Med*. 1997;336:1689–96.
322. Boersma E, Akkerhuis KM, Theroux P, et al. Platelet glycoprotein IIb/IIIa receptor inhibition in non-ST-elevation acute coronary syndromes: early benefit during medical treatment only, with additional protection during percutaneous coronary intervention. *Circulation*. 1999;100:2045–8.
323. Hamm CW, Heeschen C, Goldmann B, et al. c7E3 Fab Antiplatelet Therapy in Unstable Refractory Angina (CAPTURE) Study Investigators. Benefit of abciximab in patients with refractory unstable angina in relation to serum troponin T levels. *N Engl J Med*. 1999;340:1623–9.
324. Kastrati A, Mehilli J, Neumann FJ, et al. Abciximab in patients with acute coronary syndromes undergoing percutaneous coronary intervention after clopidogrel pretreatment: the ISAR-REACT 2 randomized trial. *JAMA*. 2006;295:1531–8.
325. Roffi M, Chew DP, Mukherjee D, et al. Platelet glycoprotein IIb/IIIa inhibitors reduce mortality in diabetic patients with non-ST-segment-elevation acute coronary syndromes. *Circulation*. 2001;104:2767–71.
326. The EPIC Investigators. Use of a monoclonal antibody directed against the platelet glycoprotein IIb/IIIa receptor in high-risk coronary angioplasty. The EPIC Investigation. *N Engl J Med*. 1994;330:956–61.
327. Valgimigli M, Percoco G, Barbieri D, et al. The additive value of tirofiban administered with the high-dose bolus in the prevention of ischemic complications during high-risk coronary angioplasty: the ADVANCE Trial. *J Am Coll Cardiol*. 2004;44:14–9.
328. EPISTENT Investigators. Randomised placebo-controlled and balloon-angioplasty-controlled trial to assess safety of coronary stenting with use of platelet glycoprotein-IIb/IIIa blockade. *Lancet*. 1998;352:87–92.
329. ESPRIT Investigators. Novel dosing regimen of eptifibatide in planned coronary stent implantation (ESPRIT): a randomised, placebo-controlled trial [published correction appears in *Lancet*. 2001;357:1370]. *Lancet*. 2000;356:2037–44.
330. Kastrati A, Mehilli J, Schuhlen H, et al. A clinical trial of abciximab in elective percutaneous coronary intervention after pretreatment with clopidogrel. *N Engl J Med*. 2004;350:232–8.
331. Mehilli J, Kastrati A, Schuhlen H, et al. Randomized clinical trial of abciximab in diabetic patients undergoing elective percutaneous coronary interventions after treatment with a high loading dose of clopidogrel. *Circulation*. 2004;110:3627–35.
332. Hausleiter J, Kastrati A, Mehilli J, et al. A randomized trial comparing phosphorylcholine-coated stenting with balloon angioplasty as well as abciximab with placebo for restenosis reduction in small coronary arteries. *J Intern Med*. 2004;256:388–97.
333. De Luca G, Cassetti E, Verdoia M, et al. Bivalirudin as compared to unfractionated heparin among patients undergoing coronary angioplasty: a meta-analysis of randomised trials. *Thromb Haemost*. 2009;102:428–36.
334. Lincoff AM, Steinhilb SR, Manoukian SV, et al. Influence of timing of clopidogrel treatment on the efficacy and safety of bivalirudin in patients with non-ST-segment elevation acute coronary syndromes undergoing percutaneous coronary intervention: an analysis of the ACUTY (Acute Catheterization and Urgent Intervention Triage strategy) trial. *J Am Coll Cardiol Interv*. 2008;1:639–48.
335. Kastrati A, Neumann FJ, Mehilli J, et al. Bivalirudin versus unfractionated heparin during percutaneous coronary intervention. *N Engl J Med*. 2008;359:688–96.
336. Lincoff AM, Bittl JA, Harrington RA, et al. Bivalirudin and provisional glycoprotein IIb/IIIa blockade compared with heparin and planned glycoprotein IIb/IIIa blockade during percutaneous coronary intervention: REPLACE-2 randomized trial. *JAMA*. 2003;289:853–63.
337. Lincoff AM, Kleiman NS, Kereiakes DJ, et al. Long-term efficacy of bivalirudin and provisional glycoprotein IIb/IIIa blockade vs heparin and planned glycoprotein IIb/IIIa blockade during percutaneous coronary revascularization: REPLACE-2 randomized trial. *JAMA*. 2004;292:696–703.
338. Mehran R, Lansky AJ, Witenbichler B, et al. Bivalirudin in patients undergoing primary angioplasty for acute myocardial infarction (HORIZONS-AMI): 1-year results of a randomised controlled trial. *Lancet*. 2009;374:1149–59.
339. Schulz S, Mehilli J, Ndrepepa G, et al. Bivalirudin vs. unfractionated heparin during percutaneous coronary interventions in patients with stable and unstable angina pectoris: 1-year results of the ISAR-REACT 3 trial. *Eur Heart J*. 2010;31:582–7.
340. Stone GW, McLaurin BT, Cox DA, et al. Bivalirudin for patients with acute coronary syndromes. *N Engl J Med*. 2006;355:2203–16.
341. Stone GW, Witenbichler B, Guagliumi G, et al. Bivalirudin during primary PCI in acute myocardial infarction. *N Engl J Med*. 2008;358:2218–30.
342. Dangas G, Mehran R, Guagliumi G, et al. Role of clopidogrel loading dose in patients with ST-segment elevation myocardial infarction undergoing primary angioplasty: results from the HORIZONS-AMI (harmonizing outcomes with revascularization and stents in acute myocardial infarction) trial. *J Am Coll Cardiol*. 2009;54:1438–46.
343. Brieger D, Collet JP, Silvain J, et al. Heparin or enoxaparin anticoagulation for primary percutaneous coronary intervention. *Catheter Cardiovasc Interv*. 2011;77:182–90.
344. Choussat R, Montalescot G, Collet JP, et al. A unique, low dose of intravenous enoxaparin in elective percutaneous coronary intervention. *J Am Coll Cardiol*. 2002;40:1943–50.
345. Collet JP, Montalescot G, Lison L, et al. Percutaneous coronary intervention after subcutaneous enoxaparin pretreatment in patients with unstable angina pectoris. *Circulation*. 2001;103:658–63.
346. Ferguson JJ, Califf RM, Antman EM, et al. Enoxaparin vs unfractionated heparin in high-risk patients with non-ST-segment elevation acute coronary syndromes managed with an intended early invasive strategy: primary results of the SYNERGY randomized trial. *JAMA*. 2004;292:45–54.
347. Montalescot G, Gallo R, White HD, et al. Enoxaparin versus unfractionated heparin in elective percutaneous coronary intervention 1-year results from the STEEPLE (SafeTy and efficacy of enoxaparin in percutaneous coronary intervention patients, an international randomized evaluation) trial. *J Am Coll Cardiol Interv*. 2009;2:1083–91.
348. Yusuf S, Mehta SR, Chrolavicius S, et al. Comparison of fondaparinux and enoxaparin in acute coronary syndromes. *N Engl J Med*. 2006;354:1464–76.
349. Yusuf S, Mehta SR, Chrolavicius S, et al. Effects of fondaparinux on mortality and reinfarction in patients with acute ST-segment elevation myocardial infarction: the OASIS-6 randomized trial. *JAMA*. 2006;295:1519–30.
350. Cohen M, Levine GN, Pieper KS, et al. Enoxaparin 0.3 mg/kg IV supplement for patients transitioning to PCI after subcutaneous enoxaparin therapy for NSTEMI ACS: a subgroup analysis from the SYNERGY trial. *Catheter Cardiovasc Interv*. 2010;75:928–35.
351. Collet JP, Montalescot G, Golmard JL, et al. Subcutaneous enoxaparin with early invasive strategy in patients with acute coronary syndromes. *Am Heart J*. 2004;147:655–61.

352. Levine GN, Ferrando T. Degree of anticoagulation after one subcutaneous and one subsequent intravenous booster dose of enoxaparin: implications for patients with acute coronary syndromes undergoing early percutaneous coronary intervention. *J Thromb Thrombolysis*. 2004;17:167–71.
353. Martin JL, Fry ET, Sanderink GJ, et al. Reliable anticoagulation with enoxaparin in patients undergoing percutaneous coronary intervention: the pharmacokinetics of enoxaparin in PCI (PEPCI) study. *Catheter Cardiovasc Interv*. 2004;61:163–70.
354. Drouet L, Bal dit Sollier C, Martin J. Adding intravenous unfractionated heparin to standard enoxaparin causes excessive anticoagulation not detected by activated clotting time: results of the STACK-on to ENOXaparin (STACKENOX) study. *Am Heart J*. 2009;158:177–84.
355. Lewis BE, Matthai WH Jr, Cohen M, et al. Argatroban anticoagulation during percutaneous coronary intervention in patients with heparin-induced thrombocytopenia. *Catheter Cardiovasc Interv*. 2002;57:177–84.
356. Mahaffey KW, Lewis BE, Wildermann NM, et al. The anticoagulant therapy with bivalirudin to assist in the performance of percutaneous coronary intervention in patients with heparin-induced thrombocytopenia (ATBAT) study: main results. *J Invasive Cardiol*. 2003;15:611–6.
357. Amit G, Cafri C, Yaroslavtsev S, et al. Intracoronary nitroprusside for the prevention of the no-reflow phenomenon after primary percutaneous coronary intervention in acute myocardial infarction. A randomized, double-blind, placebo-controlled clinical trial. *Am Heart J*. 2006;152:887.e9–887.e14.
358. Assali AR, Sdringola S, Ghani M, et al. Intracoronary adenosine administered during percutaneous intervention in acute myocardial infarction and reduction in the incidence of “no reflow” phenomenon. *Catheter Cardiovasc Interv*. 2000;51:27–31.
359. Barcin C, Denktas AE, Lennon RJ, et al. Comparison of combination therapy of adenosine and nitroprusside with adenosine alone in the treatment of angiographic no-reflow phenomenon. *Catheter Cardiovasc Interv*. 2004;61:484–91.
360. Fischell TA, Haller S, Pulurthy S, et al. Nicardipine and adenosine “flush cocktail” to prevent no-reflow during rotational atherectomy. *Cardiovasc Revasc Med*. 2008;9:224–8.
361. Hillegeass WB, Dean NA, Liao L, et al. Treatment of no-reflow and impaired flow with the nitric oxide donor nitroprusside following percutaneous coronary interventions: initial human clinical experience. *J Am Coll Cardiol*. 2001;37:1335–43.
362. Huang RI, Patel P, Walinsky P, et al. Efficacy of intracoronary nicardipine in the treatment of no-reflow during percutaneous coronary intervention. *Catheter Cardiovasc Interv*. 2006;68:671–6.
363. Ito H, Taniyama Y, Iwakura K, et al. Intravenous nicorandil can preserve microvascular integrity and myocardial viability in patients with reperfused anterior wall myocardial infarction. *J Am Coll Cardiol*. 1999;33:654–60.
364. Kaplan BM, Benzuly KH, Kinn JW, et al. Treatment of no-reflow in degenerated saphenous vein graft interventions: comparison of intracoronary verapamil and nitroglycerin. *Cathet Cardiovasc Diagn*. 1996;39:113–8.
365. Marzilli M, Orsini E, Marraccini P, et al. Beneficial effects of intracoronary adenosine as an adjunct to primary angioplasty in acute myocardial infarction. *Circulation*. 2000;101:2154–9.
366. Ono H, Osanai T, Ishizaka H, et al. Nicorandil improves cardiac function and clinical outcome in patients with acute myocardial infarction undergoing primary percutaneous coronary intervention: role of inhibitory effect on reactive oxygen species formation. *Am Heart J*. 2004;148:611.
367. Piana RN, Paik GY, Moscucci M, et al. Incidence and treatment of ‘no-reflow’ after percutaneous coronary intervention. *Circulation*. 1994;89:2514–8.
368. Ross AM, Gibbons RJ, Stone GW, et al. A randomized, double-blinded, placebo-controlled multicenter trial of adenosine as an adjunct to reperfusion in the treatment of acute myocardial infarction (AMISTAD-II). *J Am Coll Cardiol*. 2005;45:1775–80.
369. Sdringola S, Assali A, Ghani M, et al. Adenosine use during aortocoronary vein graft interventions reverses but does not prevent the slow-no reflow phenomenon. *Catheter Cardiovasc Interv*. 2000;51:394–9.
370. Stael MG, Marques KM, de Cock CC, et al. High dose adenosine for suboptimal myocardial perfusion after primary PCI: A randomized placebo-controlled pilot study. *Catheter Cardiovasc Interv*. 2008;71:283–9.
371. Werner GS, Lang K, Kuehnert H, et al. Intracoronary verapamil for reversal of no-reflow during coronary angioplasty for acute myocardial infarction. *Catheter Cardiovasc Interv*. 2002;57:444–51.
372. Weyrens FJ, Mooney J, Lesser J, et al. Intracoronary diltiazem for microvascular spasm after interventional therapy. *Am J Cardiol*. 1995;75:849–50.
373. Olivari Z, Rubartelli P, Piscione F, et al. Immediate results and one-year clinical outcome after percutaneous coronary interventions in chronic total occlusions: data from a multicenter, prospective, observational study (TOAST-GISE). *J Am Coll Cardiol*. 2003;41:1672–8.
374. Suero JA, Marso SP, Jones PG, et al. Procedural outcomes and long-term survival among patients undergoing percutaneous coronary intervention of a chronic total occlusion in native coronary arteries: a 20-year experience. *J Am Coll Cardiol*. 2001;38:409–14.
375. de Labriolle A, Bonello L, Roy P, et al. Comparison of safety, efficacy, and outcome of successful versus unsuccessful percutaneous coronary intervention in “true” chronic total occlusions. *Am J Cardiol*. 2008;102:1175–81.
376. Rathore S, Matsuo H, Terashima M, et al. Procedural and in-hospital outcomes after percutaneous coronary intervention for chronic total occlusions of coronary arteries 2002 to 2008: impact of novel guidewire techniques. *J Am Coll Cardiol Interv*. 2009;2:489–97.
377. Stone GW, Reifart NJ, Moussa I, et al. Percutaneous recanalization of chronically occluded coronary arteries: a consensus document: part II. *Circulation*. 2005;112:2530–7.
378. Roffi M, Mukherjee D, Chew DP, et al. Lack of benefit from intravenous platelet glycoprotein IIb/IIIa receptor inhibition as adjunctive treatment for percutaneous interventions of aortocoronary bypass grafts: a pooled analysis of five randomized clinical trials. *Circulation*. 2002;106:3063–7.
379. Ellis SG, Lincoff AM, Miller D, et al., EPIC and EPILOG Investigators. Reduction in complications of angioplasty with abciximab occurs largely independently of baseline lesion morphology. Evaluation of 7E3 for the Prevention of Ischemic Complications. Evaluation of PTCA to Improve Long-term Outcome with abciximab GPIIb/IIIa Receptor Blockade. *J Am Coll Cardiol*. 1998;32:1619–23.
380. Al-Lamee R, Ielasi A, Latib A, et al. Clinical and angiographic outcomes after percutaneous recanalization of chronic total saphenous vein graft occlusion using modern techniques. *Am J Cardiol*. 2010;106:1721–7.
381. de Feyter PJ, Serruys P, van den Brand M, et al. Percutaneous transluminal angioplasty of a totally occluded venous bypass graft: a challenge that should be resisted. *Am J Cardiol*. 1989;64:88–90.
382. de Feyter PJ, van Suylen RJ, de Jaegere PP, et al. Balloon angioplasty for the treatment of lesions in saphenous vein bypass grafts. *J Am Coll Cardiol*. 1993;21:1539–49.
383. Colombo A, Bramucci E, Sacca S, et al. Randomized study of the crush technique versus provisional side-branch stenting in true coronary bifurcations: the CACTUS (Coronary Bifurcations: Application of the Crushing Technique Using Sirolimus-Eluting Stents) Study. *Circulation*. 2009;119:71–8.
384. Ferenc M, Gick M, Kienzle RP, et al. Randomized trial on routine vs. provisional T-stenting in the treatment of de novo coronary bifurcation lesions. *Eur Heart J*. 2008;29:2859–67.
385. Hildick-Smith D, de Belder AJ, Cooter N, et al. Randomized trial of simple versus complex drug-eluting stenting for bifurcation lesions: the British Bifurcation Coronary Study: old, new, and evolving strategies. *Circulation*. 2010;121:1235–43.
386. Steigen TK, Maeng M, Wiseth R, et al. Randomized study on simple versus complex stenting of coronary artery bifurcation lesions: the Nordic bifurcation study. *Circulation*. 2006;114:1955–61.
387. Chen SL, Santoso T, Zhang JJ, et al. A randomized clinical study comparing double kissing crush with provisional stenting for treatment of coronary bifurcation lesions results from the DKCRUSH-II (double kissing crush versus provisional stenting technique for treatment of coronary bifurcation lesions) Trial. *J Am Coll Cardiol*. 2011;57:914–20.



388. Moussa ID. Coronary artery bifurcation interventions: the disconnect between randomized clinical trials and patient centered decision-making. *Catheter Cardiovasc Interv*. 2011;77:537–45.
389. Aliabadi D, Tili FV, Bowers TR, et al. Incidence and angiographic predictors of side branch occlusion following high-pressure intracoronary stenting. *Am J Cardiol*. 1997;80:994–7.
390. Galassi AR, Tomasello SD, Capodanno D, et al. Mini-crush versus T-provisional techniques in bifurcation lesions: clinical and angiographic long-term outcome after implantation of drug-eluting stents. *J Am Coll Cardiol*. 2009;2:185–94.
391. Gil RJ, Gziut AI, Prati F, et al. Threshold parameters of left main coronary artery stenosis based on intracoronary ultrasound examination. *Kardiol Pol*. 2005;63:223–31.
392. Sano K, Mintz GS, Carlier SG, et al. Assessing intermediate left main coronary lesions using intravascular ultrasound. *Am Heart J*. 2007;154:983–8.
393. Park DW, Hong MK, Suh IW, et al. Results and predictors of angiographic restenosis and long-term adverse cardiac events after drug-eluting stent implantation for aorto-ostial coronary artery disease. *Am J Cardiol*. 2007;99:760–5.
394. Iakovou I, Ge L, Michev I, et al. Clinical and angiographic outcome after sirolimus-eluting stent implantation in aorto-ostial lesions. *J Am Coll Cardiol*. 2004;44:967–71.
395. Brogan WCI, Popma JJ, Pichard AD, et al. Rotational coronary atherectomy after unsuccessful coronary balloon angioplasty. *Am J Cardiol*. 1993;71:794–8.
396. Biancari F, D'Andrea V, Di Marco C, et al. Meta-analysis of randomized trials on the efficacy of vascular closure devices after diagnostic angiography and angioplasty. *Am Heart J*. 2010;159:518–31.
397. Dauerman HL, Applegate RJ, Cohen DJ. Vascular closure devices: the second decade. *J Am Coll Cardiol*. 2007;50:1617–26.
398. Koreny M, Riedmuller E, Nikfardjam M, et al. Arterial puncture closing devices compared with standard manual compression after cardiac catheterization: systematic review and meta-analysis. *JAMA*. 2004;291:350–7.
399. Patel MR, Jneid H, Derdeyn CP, et al. Arteriotomy closure devices for cardiovascular procedures: a scientific statement from the American Heart Association. *Circulation*. 2010;122:1882–93.
400. Hoffer EK, Bloch RD. Percutaneous arterial closure devices. *J Vasc Interv Radiol*. 2003;14:865–85.
401. Nikolsky E, Mehran R, Halkin A, et al. Vascular complications associated with arteriotomy closure devices in patients undergoing percutaneous coronary procedures: a meta-analysis. *J Am Coll Cardiol*. 2004;44:1200–9.
402. Abraham NS, Hlatky MA, Antman EM, et al. ACCF/ACG/AHA 2010 expert consensus document on the concomitant use of proton pump inhibitors and thienopyridines. *J Am Coll Cardiol*. 2010;56:2051–66.
403. Eisenberg MJ, Blankenship JC, Huynh T, et al. Evaluation of routine functional testing after percutaneous coronary intervention. *Am J Cardiol*. 2004;93:744–7.
404. Goel K, Lennon RJ, Tilbury RT, et al. Impact of Cardiac Rehabilitation on Mortality and Cardiovascular Events After Percutaneous Coronary Intervention in the Community. *Circulation*. 2011;123:2344–52.
405. Taylor RS, Brown A, Ebrahim S, et al. Exercise-based rehabilitation for patients with coronary heart disease: systematic review and meta-analysis of randomized controlled trials. *Am J Med*. 2004;116:682–92.
406. Giannuzzi P, Temporelli PL, Marchioli R, et al. Global secondary prevention strategies to limit event recurrence after myocardial infarction: results of the GOSPEL study, a multicenter, randomized controlled trial from the Italian Cardiac Rehabilitation Network. *Arch Intern Med*. 2008;168:2194–204.
407. Witt BJ, Jacobsen SJ, Weston SA, et al. Cardiac rehabilitation after myocardial infarction in the community. *J Am Coll Cardiol*. 2004;44:988–96.
408. Fletcher GF, Balady GJ, Amsterdam EA, et al. Exercise standards for testing and training: a statement for healthcare professionals from the American Heart Association. *Circulation*. 2001;104:1694–740.
409. Thompson PD. Exercise and physical activity in the prevention and treatment of atherosclerotic cardiovascular disease. *Arterioscler Thromb Vasc Biol*. 2003;23:1319–21.
410. Clark AM, Hartling L, Vandermeer B, et al. Meta-analysis: secondary prevention programs for patients with coronary artery disease. *Ann Intern Med*. 2005;143:659–72.
411. Thomas RJ, King M, Lui K, et al. AACVPR/ACC/AHA 2007 performance measures on cardiac rehabilitation for referral to and delivery of cardiac rehabilitation/secondary prevention services. *J Am Coll Cardiol*. 2007;50:1400–33.
412. Walther C, Mobius-Winkler S, Linke A, et al. Regular exercise training compared with percutaneous intervention leads to a reduction of inflammatory markers and cardiovascular events in patients with coronary artery disease. *Eur J Cardiovasc Prev Rehabil*. 2008;15:107–12.
413. Smith SC Jr., Benjamin EJ, Bonow RO, et al. AHA/ACCF secondary prevention and risk reduction therapy for patients with coronary and other atherosclerotic vascular disease: 2011 update: a guideline from the American Heart Association and American College of Cardiology Foundation. *Circulation*, published online before print November 3, 2011, doi:10.1161/CIR.0b013e318235eb4d. Accessed November 3, 2011.
414. Third report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III) final report. *Circulation*. 2002;106:3143–421.
415. Dattilo AM, Kris-Etherton PM. Effects of weight reduction on blood lipids and lipoproteins: a meta-analysis. *Am J Clin Nutr*. 1992;56:320–8.
416. Baigent C, Blackwell L, Emberson J, et al. Efficacy and safety of more intensive lowering of LDL cholesterol: a meta-analysis of data from 170,000 participants in 26 randomised trials. *Lancet*. 2010;376:1670–81.
417. Pedersen TR, Faergeman O, Kastelein JJ, et al. High-dose atorvastatin vs usual-dose simvastatin for secondary prevention after myocardial infarction: the IDEAL study: a randomized controlled trial. *JAMA*. 2005;294:2437–45.
418. LaRosa JC, Grundy SM, Waters DD, et al. Intensive lipid lowering with atorvastatin in patients with stable coronary disease. *N Engl J Med*. 2005;352:1425–35.
- 419a. Cholesterol Treatment Trialists' (CTT) Collaboration, Baigent C, Blackwell L, et al. Efficacy and safety of more intensive lowering of LDL cholesterol: a meta-analysis of data from 170,000 participants in 26 randomised trials. *Lancet*. 2010;376:1670–81.
419. MRC/BHF Heart Protection Study of cholesterol lowering with simvastatin in 20,536 high-risk individuals: a randomised placebo-controlled trial. *Lancet*. 2002;360:7–22.
420. Cannon CP, Braunwald E, McCabe CH, et al. Intensive versus moderate lipid lowering with statins after acute coronary syndromes. *N Engl J Med*. 2004;350:1495–504.
421. Cannon CP, Steinberg BA, Murphy SA, et al. Meta-analysis of cardiovascular outcomes trials comparing intensive versus moderate statin therapy. *J Am Coll Cardiol*. 2006;48:438–45.
422. Grundy SM, Cleeman JI, Merz CN, et al. Implications of recent clinical trials for the National Cholesterol Education Program Adult Treatment Panel III guidelines. *Circulation*. 2004;110:227–39.
423. Chobanian AV, Bakris GL, Black HR, et al. Seventh report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure. *Hypertension*. 2003;42:1206–52.
424. Whelton SP, Chin A, Xin X, et al. Effect of aerobic exercise on blood pressure: a meta-analysis of randomized, controlled trials. *Ann Intern Med*. 2002;136:493–503.
425. Appel LJ, Frohlich ED, Hall JE, et al. The importance of population-wide sodium reduction as a means to prevent cardiovascular disease and stroke: a call to action from the American Heart Association. *Circulation*. 2011;123:1138–43.
426. Sacks FM, Svetkey LP, Vollmer WM, et al., DASH-Sodium Collaborative Research Group. Effects on blood pressure of reduced dietary sodium and the Dietary Approaches to Stop Hypertension (DASH) diet. *N Engl J Med*. 2001;344:3–10.
427. Appel LJ, Moore TJ, Obarzanek E, et al., for the DASH Collaborative Research Group. A clinical trial of the effects of dietary patterns on blood pressure. *N Engl J Med*. 1997;336:1117–24.
428. The ALLHAT Officers and Coordinators for the ALLHAT Collaborative Research Group. Major outcomes in high-risk hypertensive patients randomized to angiotensin-converting enzyme inhibitor or calcium channel blocker vs diuretic: the Antihypertensive and Lipid-Lowering Treatment to Prevent Heart Attack Trial (ALL-

- Key Words:** ACCF/AHA Practice Guidelines ■ acute coronary syndromes ■ anticoagulants ■ antiplatelet agents ■ arrhythmias, cardiac ■ coronary angiography ■ coronary artery revascularization interventions: stents ■ drug therapy ■ heart diseases ■ myocardial revascularization ■ platelet aggregation inhibitor ■ ultrasound.

## APPENDIX 1. AUTHOR RELATIONSHIPS WITH INDUSTRY AND OTHER ENTITIES (RELEVANT)—2011 ACCF/AHA/SCAI GUIDELINE FOR PERCUTANEOUS CORONARY INTERVENTION

[illegible]

Committee Member	Employer/Title	Consultant	Speaker's Bureau	Ownership/ Partnership/ Principal	Personal Research	Institutional, Organizational, or Other Financial Benefit	Expert Witness	Voting Recusals by Section Number*
Charles E. Chambers	Penn State Milton S. Hershey Medical Center—Professor of Medicine and Radiology	None	None	None	None	None	None	None
Stephen G. Ellis	Cleveland Clinic Foundation—Section Head, Invasive and Interventional Cardiology	<ul style="list-style-type: none"> <li>• Abbott Vascular</li> <li>• Boston Scientific</li> <li>• Cordis</li> <li>• Daiichi-Sankyo</li> <li>• Eli Lilly</li> </ul>	None	None	<ul style="list-style-type: none"> <li>• Abbott Vascular</li> </ul>	None	None	2.2 2.11 5.7.2 6.1
Robert A. Guyton	Emory Clinic, Inc.—Professor and Chief, Division of Cardiothoracic Surgery	None	None	None	<ul style="list-style-type: none"> <li>• Edwards Lifesciences</li> </ul>	None	None	2.1 2.2 2.3 2.9.7 2.11 5.2.4 5.3 5.5.5 6.2 6.3
Steven M. Hollenberg	Cooper University Hospital—Director, Coronary Care Unit	<ul style="list-style-type: none"> <li>• Eisai</li> </ul>	None	None	None	None	None	5.7.4.3
Umesh N. Khot	CV Research Innovations, LLC—President/CEO	None	None	<ul style="list-style-type: none"> <li>• Merck†</li> </ul>	None	None	None	4.6 5.7.3
Richard A. Lange	University of Texas Health Science Center at San Antonio—Professor of Medicine	None	None	None	None	None	None	None
Laura Mauri	Brigham and Women's Hospital—Associate Professor of Medicine, Harvard Medical School	<ul style="list-style-type: none"> <li>• Abbott</li> <li>• Conor Medsystems (Johnson &amp; Johnson)</li> <li>• Cordis</li> <li>• Medtronic</li> </ul>	None	None	<ul style="list-style-type: none"> <li>• Lutonix</li> </ul>	<ul style="list-style-type: none"> <li>• Abbott</li> <li>• Abiomed</li> <li>• Boston Scientific</li> <li>• Bristol-Myers Squibb</li> <li>• Conor Medsystems</li> <li>• Cordis</li> <li>• Daiichi-Sankyo</li> <li>• Eli Lilly</li> <li>• Medtronic Cardiovascular</li> <li>• Sanofi-aventis</li> </ul>	<ul style="list-style-type: none"> <li>• Defendant, Conor, interpretation of clinical trial results, 2010</li> </ul>	2.9.7 5.2.3 5.3 5.4.2 5.5.1 5.5.2 5.5.4 5.5.5 5.6 5.7.2 5.7.3 5.8.2 5.8.4 5.8.5 5.11 6.1 6.1.2 6.1.3 6.2
Roxana Mehran	Columbia University Medical Center—Associate Professor of Medicine; Director, Data Coordinating Analysis Center	<ul style="list-style-type: none"> <li>• Abbott Vascular</li> <li>• Abiomed</li> <li>• AlphaMedical</li> <li>• AstraZeneca</li> <li>• Bracco</li> <li>• BMS/sanofi-aventis</li> <li>• DataScope</li> <li>• Eli Lilly/Daiichi-Sankyo</li> <li>• Guerbet</li> <li>• The Medicines Company</li> <li>• Medtronic Vascular</li> <li>• St. Jude</li> </ul>	None	None	None	None	None	4.7 5.1 5.2.4 5.3 5.4.1 5.4.2 5.5.1 5.5.2 5.6 5.7.2 5.7.3 5.7.4.1 5.7.4.2 5.7.4.3 5.7.4.4 5.7.4.5 5.8.3 5.8.4 5.11 6.1 6.1.1 6.1.2 6.1.3

Committee Member	Employer/Title	Consultant	Speaker's Bureau	Ownership/ Partnership/ Principal	Personal Research	Institutional, Organizational, or Other Financial Benefit	Expert Witness	Voting Recusals by Section Number*
Issam D. Moussa	Mayo Clinic—Professor of Medicine; Chair, Division of Cardiovascular Diseases	None	None	None	None	None	None	None
Debabrata Mukherjee	Texas Tech University—Chief, Cardiovascular Medicine	None	None	None	None	None	None	None
Brahmajee K. Nallamothu	University of Michigan—Assistant Professor of Medicine	None	None	None	None	None	None	None
Henry H. Ting	Mayo Clinic—Professor of Medicine; Assistant Dean for Quality	None	None	None	None	None	None	None

This table represents the relationships of committee members with industry and other entities that were determined to be relevant to this document. These relationships were reviewed and updated in conjunction with all meetings and/or conference calls of the writing committee during the document development process. The table does not necessarily reflect relationships with industry at the time of publication. A person is deemed to have a significant interest in a business if the interest represents ownership of  $\geq 5\%$  of the voting stock or share of the business entity, or ownership of  $\geq \$10,000$  of the fair market value of the business entity; or if funds received by the person from the business entity exceed 5% of the person's gross income for the previous year. Relationships that exist with no financial benefit are also included for the purpose of transparency. Relationships in this table are modest unless otherwise noted.

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\*Writing committee members are required to recuse themselves from voting on sections to which their specific relationships with industry and other entities may apply. Section numbers apply to the full-text guideline. †Significant relationship.

## APPENDIX 2. REVIEWER RELATIONSHIPS WITH INDUSTRY AND OTHER ENTITIES (RELEVANT)— 2011 ACCF/AHA/SCAI GUIDELINE FOR PERCUTANEOUS CORONARY INTERVENTION

Peer Reviewer	Representation	Consultant	Speaker's Bureau	Ownership/ Partnership/ Principal	Personal Research	Institutional, Organizational, or Other Financial Benefit	Expert Witness
Deepak L. Bhatt	Official Reviewer—AHA	None	None	None	<ul style="list-style-type: none"> <li>• AstraZeneca*</li> <li>• Bristol-Myers Squibb*</li> <li>• Eisai*</li> <li>• Eli Lilly</li> <li>• Ethicon*</li> <li>• The Medicines Company*</li> <li>• PLx Pharma†</li> <li>• Sanofi-aventis*</li> </ul>	None	None
Mauricio G. Cohen	Official Reviewer—AHA	<ul style="list-style-type: none"> <li>• AstraZeneca*</li> <li>• Momenta Pharma</li> <li>• Xoma</li> </ul>	<ul style="list-style-type: none"> <li>• Terumo Medical</li> </ul>	None	<ul style="list-style-type: none"> <li>• Invitrox*</li> </ul>	None	None
John P. Erwin III	Official Reviewer—ACCF/AHA Task Force on Performance Measures	None	None	None	None	None	None
Kirk Garratt	Official Reviewer—SCAI	<ul style="list-style-type: none"> <li>• Boston Scientific</li> <li>• Cordis/Johnson &amp; Johnson</li> <li>• The Medicines Company</li> </ul>	<ul style="list-style-type: none"> <li>• Boston Scientific</li> <li>• BMS/sanofi-aventis*</li> <li>• Daiichi-Sankyo/Eli Lilly*</li> <li>• Medtronic</li> <li>• The Medicines Company</li> </ul>	<ul style="list-style-type: none"> <li>• Abbott Vascular</li> <li>• Boston Scientific</li> </ul>	None	None	None
Steven L. Goldberg	Official Reviewer—SCAI	<ul style="list-style-type: none"> <li>• AGA</li> </ul>	<ul style="list-style-type: none"> <li>• Bristol-Myers Squibb</li> <li>• Sanofi-aventis</li> </ul>	None	None	None	<ul style="list-style-type: none"> <li>• Plaintiff, patient litigation, 2010</li> </ul>



Peer Reviewer	Representation	Consultant	Speaker's Bureau	Ownership/ Partnership/ Principal	Personal Research	Institutional, Organizational, or Other Financial Benefit	Expert Witness
Alice K. Jacobs	Official Reviewer—ACCF/AHA Task Force on Practice Guidelines	None	None	• Wyeth*	• Abbott Vascular* • Abiomed* • Accumetrics* • Cardiovascular Research Foundation (DSMB)† • Harvard Clinical Research Institute† • TIMI Study Group (DSMB)†	None	None
G.B. John Mancini	Official Reviewer—ACCF Board of Governors	• GlaxoSmithKline • Merck • Pfizer • Sanofi-aventis	None	None	• Merck*	None	None
W. Douglas Weaver	Official Reviewer—ACCF Board of Trustees	None	None	None	• Boehringer Ingelheim (DSMB) • Boston Scientific (DSMB) • Duke Clinical Research Institute (Johnson & Johnson/Schering Plough)* • GlaxoSmithKline • NHLBI (DSMB) • TIMI Study Group (Johnson & Johnson/Bayer-DSMB)	None	None
Thomas M. Bashore	Content Reviewer	None	None	None	None	None	None
Christopher E. Buller	Content Reviewer	• Abbott Vascular • Toshiba Medical	None	None	• Novartis • Regado Biosciences	None	None
James A. Burke	Content Reviewer—ACCF Interventional Scientific Council	None	None	None	None	None	None
John G. Byrne	Content Reviewer—ACCF Surgeons' Scientific Council	• Edwards Lifesciences	None	None	None	None	None
T. Bruce Ferguson	Content Reviewer—ACCF Surgeons' Scientific Council	None	None	None	• Novadaq Technologies*	None	None
Victor A. Ferrari	Content Reviewer	None	None	None	• NHLBI (DSMB)† • National Institute for Aging/NIH (DSMB)†	None	None
John G. Harold	Content Reviewer	None	None	None	None	None	None
Biswajit Kar	Content Reviewer	None	None	None	• AstraZeneca† • Boston Scientific† • Medtronic†	• Veterans Affairs Cooperative Study†	None

Peer Reviewer	Representation	Consultant	Speaker's Bureau	Ownership/ Partnership/ Principal	Personal Research	Institutional, Organizational, or Other Financial Benefit	Expert Witness
Morton J. Kern	Content Reviewer	• Infraredex • Merit Medical*	• St. Jude Medical* • Volcano Therapeutics*	None	None	None	None
Spencer B. King III	Content Reviewer	• Celonova Biosciences†	None	None	• Merck (DSMB) • Wyeth (DSMB)	None	None
Frederick G. Kushner	Content Reviewer	None	None	None	• Novartis†	None	None
David J. Maron	Content Reviewer	None	None	• Cardiovascular Care Affiliates*	None	None	• Plaintiff, acute coronary syndrome, 2010
Douglass A. Morrison	Content Reviewer	None	None	None	None	None	None
Thomas C. Piemonte	Content Reviewer—ACCF Board of Governors	None	None	None	None	None	• Defendant, stent perforation, 2010
Peter K. Smith	Content Reviewer	• Eli Lilly	None	None	None	None	None
Sidney C. Smith	Content Reviewer	None	None	None	None	None	None
Richard W. Snyder	Content Reviewer—ACCF Board of Governors	None	None	None	None	• Hospital Corporation of America	None
Patrick L. Whitlow	Content Reviewer	• Edwards Lifesciences* • eValve* • Medtronic*	None	None	None	• ICON	None
David O. Williams	Content Reviewer	• Light Lab/St. Jude Medical	None	None	None	None	None
R. Scott Wright	Content Reviewer	• Hoffman LaRoche*	None	None	None	None	None

This table represents the relationships of reviewers with industry and other entities that were disclosed at the time of peer review and determined to be relevant. It does not necessarily reflect relationships with industry at the time of publication. A person is deemed to have a significant interest in a business if the interest represents ownership of  $\geq 5\%$  of the voting stock or share of the business entity, or ownership of  $\geq \$10,000$  of the fair market value of the business entity; or if funds received by the person from the business entity exceed 5% of the person's gross income for the previous year. A relationship is considered to be modest if it is less than significant under the preceding definition. Relationships that exist with no financial benefit are also included for the purpose of transparency. Relationships in this table are modest unless otherwise noted. Names are listed in alphabetical order within each category of review.

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\*Significant relationship. †No financial benefit.

ACCF indicates American College of Cardiology Foundation; AHA, American Heart Association; DSMB, data safety and monitoring board; NHLBI, National Heart, Lung, and Blood Institute; NIH, National Institutes of Health; SCAI, Society for Cardiovascular Angiography and Interventions; and TIMI, Thrombolysis In Myocardial Infarction.